WEATHER MODIFICATION RESEARCH

UNIVERSITY OF MICHIGAN
APR
MAIN READING ROOM

HEARINGS

BEFORE A

SUBCOMMITTEE OF THE COMMITTEE ON INTERSTATE AND FOREIGN COMMERCE HOUSE OF REPRESENTATIVES

EIGHTY-FIFTH CONGRESS

SECOND SESSION

ON

S. 86

AN ACT TO PROVIDE FOR A RESEARCH PROGRAM IN THE FIELD OF WEATHER MODIFICATION TO BE CONDUCTED BY THE NATIONAL SCIENCE FOUNDATION, AND FOR OTHER PURPOSES

MARCH 18 AND 19, 1958

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CONTENTS

	Page
Text of—	
H. R. 3631	3
S. 86	3
Report of—	
Agriculture Department	5
Bureau of the Budget	7
Commerce Department	6
Interior Department	5
National Science Foundation	4
Statement of—	
Baring, Hon. Walter S., a Representative in Congress from the State of Nevada	22
Berry, Hon. E. Y., a Representative in Congress from the State of South Dakota	14
Case, Hon. Francis H., a United States Senator from the State of South Dakota	7
Di Santo, John L., field director, Water Resources Development Corp., Denver, Colo	54
Dixon, Hon. Henry Aldous, a Representative in Congress from the State of Utah	18
Eberle, A. M., dean of agriculture, South Dakota State College	53
Grasmick, Dave, chairman, North Platte Valley Hail Suppression, Inc., Morrill, Nebr	70
Hoff, William, General Counsel, National Science Foundation	25
Hull, Hon. W. R., Jr., a Representative in Congress from the State of Missouri	22
Klopsteg, Dr. Paul, Associate Director (Research), National Science Foundation	25
McGovern, Hon. George S., a Representative in Congress from the State of South Dakota	41
Oppenheimer, Jack C., Office of the Solicitor, Department of the Interior	57
Orville, Howard T., technical consultant, Fries instrument division, Bendix Aviation Corp., Baltimore, Md	44
Ostenberg, Clive, Chamber of Commerce, Scottsbluff, Nebr	71
Quate, Boyd, president, Weather Engineers, Inc., Sacramento, Calif	74
Reichelderfer, Dr. Francis W., Chief, Weather Bureau, Department of Commerce	33
Rogers, Hon. Paul G., a Representative in Congress from the State of Florida	24
Schreiber, Walter G., president, Hudson Valley Crop Services Co-op, Inc., Red Hook, N. Y	77
Vonnegut, Bernard, scientist, Arthur D. Little, Inc., Cambridge, Mass	80
Additional information submitted for the record by—	
American Farm Bureau Federation, telegram from Matt Triggs, assistant legislative director	90
American Meteorological Society, statement of	91
American Sugar Cane League of the United States of America, Inc., statement of Josiah Ferris, vice president	15
Amiss, Thomas L., letter from	88
Cunningham, Morrison B., director of public works, Oklahoma City, Okla., letter from	86
Forest Farmers Association, telegram from Walter Myers, executive director	90
Iowa State College of Agriculture and Mechanic Arts, letter from James H. Jensen, provost	83

Additional information submitted for the record by—Continued Page

Langfitt, Merrill J., statement of ... 38
Merewether, Arthur F., letter from ... 87
Mitchell, Albert K., telegram from ... 90
National Science Foundation:
  Draft of proposed amendment ... 29
  Statement of Alan T. Waterman, Director ... 25
New York Farm Bureau, letter from E. S. Foster, executive secretary ... 89
New York State Horticultural Society, statement of Ralph R. Smith, president ... 79
Oppenheimer, Jack C.: Legislative recommendations of Advisory Committee on Weather Control ... 57
Orville, Howard T.:
  Excerpts from report of Advisory Committee on Weather Control ... 45
  Information sheet for the press, Advisory Committee on Weather Control ... 48
  The impact of weather control on the cold war ... 51
Quate, Boyd: States having greatest hail damage, 1944–53, tabulation ... 75
Red River Valley Water Resources, Inc., letter from Floyd E. Valentine, president ... 91
Schaeffer, Vincent J., telegram from ... 90
Scottsbluff (Nebr.) Chamber of Commerce, letter from A. B. Goodwin, secretary-manager ... 72
Stout, Glenn E., statement of ... 83
Vonnegut, Bernard: Recommendations for a national institute for atmospheric research ... 81
Water Resources Development Corp.:
  Letter from Irving P. Krick, president ... 59
  Statement of Paul J. Caubin, secretary-treasurer ... 92
Weather Modification Co.:
  Statement of Charles A. O'Hanlon, president ... 85
  Telegram from ... 90

WEATHER MODIFICATION RESEARCH

TUESDAY, MARCH 18, 1958

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON HEALTH AND SCIENCE
OF THE COMMITTEE ON INTERSTATE AND FOREIGN COMMERCE,
Washington, D. C.

The subcommittee met, pursuant to notice, at 10 a. m., in room 1334, New House Office Building, Washington, D. C., Hon. George M. Rhodes (acting chairman of the subcommittee) presiding.

Mr. HARRIS. Let the committee come to order, please.

The committee is meeting this morning to initiate hearings on Senate bill 86 to provide for a research program in the field of weather modification to be conducted by the National Science Foundation.

I might say, as chairman of the committee, that my attention has been called to the importance of this legislation. I have endeavored to schedule the program that it might be considered. I know the sponsors of this legislation have been anxious for hearings now for several weeks. Unfortunately, the members of the committee have been engaged in another matter over the last few weeks. Until we could get our program a little better arranged it has not been possible to start hearings on this and some other legislation.

But some 10 days ago or so I announced to the full membership of the committee that it was my purpose to schedule hearings and asked other members of the committee who are not engaged in the problem of legislative oversight, and so forth, to bear with me and cooperate with us in conducting hearings on this very important legislation.

I considered this, in view of the information that had been brought to me, one of the most important bills that we had pending before us, on which reports have been obtained, and thus are in a position to conduct hearings.

I regret the chairman of the subcommittee, Mr. John Bell Williams, is not here this morning because of illness. He called a few minutes ago or had his office call and consequently I have asked Mr. George Rhodes of Pennsylvania to take over this hearing for us.

I appreciate the members who are here and the others who will be here in a few minutes cooperating in this. I know that with the outstanding witnesses we have on our schedule, we will get the information we need to consider this important legislation.

I am glad to note that we have Senator Case of South Dakota here to express his interest in this legislation. He had told me some time ago how important he considers this legislation. Other people, including some scientists we have talked to, also are here.

I note our colleagues in the House who are sponsors of this bill, Mr. Berry, Mr. Baring, Mr. Dixon, and Mr. Wharton are witnesses. I assume, Mr. Acting Chairman, you will be calling on them first.

Is Dr. Waterman here?

Dr. KLOPSTEG. I am substituting for him. He is not here. My name is Klopsteg, Dr. Paul Klopsteg.

Mr. HARRIS. We have a number of witnesses on our schedule which the chairman will get to as soon as possible.

With that brief statement, I hope my colleagues here will understand it is necessary for me to go to another meeting now as they are waiting there now with some important witnesses from out of the city. I will relinquish the chair to Mr. Rhodes with my thanks.

Senator CASE. Mr. Chairman, would you permit me to express my appreciation of the arrangements you have made: I think everyone here recognizes your responsibilities as chairman of the full committee with the important work you are doing there. No one wants to interfere with that but because of the importance and pressure of that I particularly want to express for the record my appreciation of your being here to open the hearings and the arrangements you have made for these witnesses to be heard.

Mr. HARRIS. Thank you very much. I am very much interested in this program and I want to see the hearings develop this subject fully and completely as I know they will. Two members of the subcommittee are tied up in another meeting, but the other members of this subcommittee I am sure will cooperate to the fullest extent in developing this and considering it so that it can be sent to us in the full committee.

We have before us a report from the Department of Agriculture, which the chairman will have placed in the record, and the reports from the Bureau of the Budget and the Secretary of Commerce, all of which are favorable, which indicates as far as we know there is no opposition to the legislation.

Mr. RHODES. Thank you, Mr. Harris. We are sorry that Chairman Harris cannot stay with us. We know his great interest in this legislation. We also understand his responsibilties in the Legislative Oversight Committee.

The subcommittee is meeting this morning to hold hearings on S. 86. This legislation would provide for an experimental research program in weather modification, to continue and expand a study started in 1954 by the Advisory Committee on Weather Control.

The Advisory Committee on Weather Control was a temporary agency established by act of Congress to study and evaluate various experiments in rainmaking.

The committee set up by Public Law 256, 83d Congress, went out of existence December 31, 1957. In its final report to the President the committee recommended the enactment of S. 86 to set up a program of weather research.

As originally introduced, S. 86 provided for a $5 million 5-year cooperative Federal-State cloud modification research program by the Advisory Committee on Weather Control. Identical bills were introduced in the House. These bills are H. R. 3631 by Congressman Hull, H. R. 5232 by Congressman Berry, H. R. 5954 by Congressman Baring, and H. R. 5958 by Congressman Engle.

Without objection, the text of these bills, identical to S. 86 as introduced, will be inserted in the record at this point as follows:

(The bills follow:)

[H. R. 3631, 85th Cong., 1st sess.]

A BILL To provide for an experimental research program in cloud modification

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That, for a period of five years following the effective date of this Act, the Advisory Committee on Weather Control be authorized and directed to formulate a program of experimental research in the field of cloud modification with special reference to areas in the States that have suffered from shortage of natural rainfall.

SEC. 2. The experimental research program authorized by this Act shall be carried on either by contracts between the Advisory Committee on Weather Control and private or public agencies and through cooperative programs with State agencies, including land-grant colleges or other State agencies to be designated by the governor of the State.

SEC. 3. There is hereby authorized to be appropriated a sum not exceeding $5,000,000 for the accomplishment of the program herein authorized: *Provided*, That of the amount appropriated annually during the five years for which this program is authorized, one-fourth shall be available for that part of the program to be accomplished by contract and three-fourths shall be available for the cooperative program to be matched equally by the States.

SEC. 4. This Act may be cited as the "Cloud Modification Research Act of 1957".

(NOTE.—H. R. 5232, H. R. 5954, and H. R. 5958 are identical with H. R. 3631.)

Mr. RHODES. Hearings were held last year by a subcommittee of the Senate Committee on Interstate and Foreign Commerce. After considering the extensive testimony taken in the hearings, the committee amended S. 86 to provide for a research program in weather modification under the National Science Foundation, a permanent operating agency of the Government. Under the revised bill, research would not be restricted to cloud modification, as provided in the original legislation, but would be expanded to embrace other phases of weather modification, including the suppressing or diminishing of hail, lightning, fog, smog, and tornadoes.

The amended bill was passed by the Senate unanimously last August. A companion bill, H. R. 9246, was introduced by Congressman Dixon.

Without objection, the bill as passed by the Senate will be included in the record at this point, together with reports from agencies of the executive branch whose comments were requested by the committee.

(The bill and reports follow:)

[S. 86, 85th Cong., 1st sess.]

AN ACT To provide for a research program in the field of weather modification to be conducted by the National Science Foundation, and for other purposes

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, The National Science Foundation is authorized and directed to initiate and support a program of study, research, and evaluation in the field of weather modification, giving particular attention to areas that have experienced floods, drought, hail, lightning, fog, tornadoes, or other weather phenomena, and to report annually to the President and the Congress thereon. In conducting such studies, the Foundation shall consult with meteorologists and scientists in private life and with agencies of Government interested in, or affected by, experimental research in the field of weather control. Research programs to carry out the purposes of this Act by the National Science Foundation, and by other Government agencies or departments, may be accomplished through contract with, or grants to, private or public institutions or agencies, including but not limited to cooperative programs with any State through such instrumentalities as may be designated by the governor of such State.

SEC. 2. For the purposes of this Act, the Foundation is authorized to accept as a gift, money, material, or services: *Provided*, That any such gift may, if the donor so specifies, be restricted or limited for use in connection with certain projects or areas. Other agencies of the Government are authorized to loan, without reimbursement, and the Foundation is authorized to receive, such property and personnel as may be deemed useful, with the approval of the Director of the Bureau of the Budget. In addition to the authority contained herein, the National Science Foundation, for the purposes of this Act, may utilize any of the powers granted by the National Science Foundation Act of 1950 (42 U. S. C. 1861–75).

SEC. 3. The Advisory Committee on Weather Control is abolished effective December 31, 1957, and its functions, duties, and records and any unexpended funds are transferred to the National Science Foundation and there is authorized to be appropriated to the National Science Foundation, such amounts as are necessary to carry out the purposes of this Act.

Passed the Senate August 5 (legislative day, July 8), 1957.

Attest:

FELTON M. JOHNSTON, *Secretary.*

NATIONAL SCIENCE FOUNDATION,
OFFICE OF THE DIRECTOR,
Washington, D. C., March 17, 1958.

HON. OREN HARRIS,
Congress of the United States,
House of Representatives, Washington, D. C.

MY DEAR MR. HARRIS: This is in reply to your letter of August 12, 1957, requesting the comments of the National Science Foundation with regard to S. 86, a bill to provide for a research program in the field of weather modification to be conducted by the National Science Foundation, and for other purposes.

We are familiar with the problems involved not only because of the work of the National Science Foundation in supporting research in the field of meteorology but also through my membership on the Advisory Committee on Weather Control.

From the evaluation activities of the Advisory Committee, evidence to date seems clearly to indicate, except under certain very special conditions of topography, temperature, and other favorable factors, that no large or important rain-producing effects will be achieved by present means without further research to acquire a better understanding of the process by which nature produces precipitation of rain or snow. It is my view, both from the studies of the committee and from consideration given to the subject in the Foundation, that by far the the most important element toward effective progress in weather modification at this time lies in a planned program in support of research by competent scientists on the fundamental problems dealing with the precipitation process. Such studies should be conducted under controlled laboratory conditions and also by carefully planned field experiments. The latter may consist of studies into the conditions under which precipitation occurs naturally and also of studies to determine the factors involved in the effects of man-made attempts to duplicate or augment natural processes. Plans for the latter type of field experiment should include authoritative means for statistical analysis and evaluation, a difficult task.

However, we would like to recommend that a section be added to S. 86 authorizing the National Science Foundation to require by subpena information necessary to carry out its provisions. An example of the kind of language which would be appropriate for this purpose is to be found in section 9 (d) of Public Law 256, 83d Congress, 1st session, establishing the Advisory Committee on Weather Control.

It would seem unwise to attempt to embark upon any program having as its aim the development of a means of weather modification until we have some scientific assurance that such a means is practical and feasible. For these reasons, we advocate enactment of S. 86, which would specifically authorize a systematic research program aimed at securing the answers we need in the general area of weather modification. The National Science Foundation intends to press for further effective research on this general subject. If S. 86 becomes law, the cooperation of other permanent agencies of the Federal Govern-

ment would be actively sought in carrying out such plans for practical developments as might arise out of fundamental research.

The Bureau of the Budget has advised us that it has no objection to the submission of this report.

Sincerely yours,

ALAN T. WATERMAN, *Director.*

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D. C., March 18, 1958.

HON. OREN HARRIS,
Chairman, Committee on Interstate and Foreign Commerce,
House of Representatives, Washington, D. C.

DEAR MR. HARRIS: This responds to your requests for the views of this Department on S. 86 and H. R. 9246, identical bills to provide for a research program in the field of weather modification to be conducted by the National Science Foundation, and for other purposes.

We recommend the enactment of either bill.

These proposals would authorize the National Science Foundation to undertake and administer a research program in weather modification. The research program would be executed by making grants to, or contracts with, public or private institutions or agencies, as well as by arranging for cooperative programs with States. Provision is made for consultation with other interested Government agencies, and for the loan and utilization of personnel and property of other Government agencies, with the approval of the Director of the Bureau of the Budget. Annual reports would be required to be made to the President and to the Congress. Section 3 of the bills would abolish, as of December 31, 1957, the Advisory Committee on Weather Control, and transfer its functions, duties, records, and unexpended funds to the National Science Foundation.

In view of the various authorized natural resources programs for which the Department of the Interior is responsible, we have a definite interest in any work which affects water supplies and resources, and we would encourage the undertaking of any reasonable measures which will lead to the alleviation of water shortages, particularly in the arid States of the West, by bringing a supply of water where it is needed when it is needed. For these reasons, we have followed with more than a casual interest the experimental work being conducted in the weather modification field.

It is our opinion that there is now a great need to obtain a better understanding of the basic physical principles involved in the precipitation process. If actual cloud-seeding operations are to be continued, we should know, in the first instance, the mechanism by which natural precipitation occurs and the manner in which cloud nucleation acts. We recognize that at an appropriate time there may be a need for well-controlled, large-scale cloud-seeding experiments to which the basic research data could be applied.

Research of this kind involves long-term programing. For this reason, we favor placing general administrative responsibility in the National Science Foundation, which is devoted to administering various scientific research programs and which has had substantial experience in working with educational institutions and other public and private research organizations.

The Bureau of the Budget has advised that there is no objection to the submission of this report to your committee.

Sincerely yours,

FRED G. AANDAHL,
Assistant Secretary of the Interior.

DEPARTMENT OF AGRICULTURE,
Washington, D. C., March 18, 1958.

Hon. OREN HARRIS,
Chairman, Committee on Interstate and Foreign Commerce,
House of Representatives.

DEAR CONGRESSMAN HARRIS: This is in reply to your requests of August 12 and 16, 1957, for reports on S. 86 and H. R. 9246, identical bills entitled, "To provide for a research program in the field of weather modification to be conducted by the National Science Foundation, and for other purposes."

The Department of Agriculture has no objection to the enactment of S. 86, as passed by the Senate or H. R. 9246, as introduced in the House.

The bills authorize the National Science Foundation to complete the evaluation work of the Advisory Committee on Weather Control and to undertake an orderly research program in weather modification. The bills would provide for the Foundation to initiate and support a program of study, research, and evaluation in the field of weather modification, giving particular attention to areas that have experienced floods, drought, hail, lightning, fog, tornadoes, or other weather phenomena. In conducting these studies, the Foundation would consult with meteorologists and scientists and with governmental agencies interested in, or affected by, experimental research in the field of weather control.

The availability of water for agricultural use is increasingly urgent, especially in those areas where population growth and growth of industry compete with agriculture for limited supplies. The thousands of forest fires started by lightning storms every year cause substantial damage to the Nation's forest resources. Basic information necessary to develop adequate means of weather modification is lacking. The National Science Foundation could, under the provisions of either bill, undertake the support of the basic research necessary for the development of the needed information.

The Bureau of the Budget advises that there is no objection to the submission of this report.

Sincerely yours,

E. T. BENSON, *Secretary.*

THE SECRETARY OF COMMERCE,
Washington, D. C., March 17, 1958.

Hon. OREN HARRIS,
Chairman, Committee on Interstate and Foreign Commerce,
House of Representatives, Washington, D. C.

DEAR MR. CHAIRMAN: This letter is in reply to your request of August 12, 1957, for the views of this Department with respect to S. 86, an act to provide for a research program in the field of weather modification to be conducted by the National Science Foundation, and for other purposes.

S. 86 would authorize and direct the National Science Foundation to initiate and support a program of study, research, and evaluation of weather modification, and would abolish the Advisory Committee on Weather Control.

This Department recommends enactment of S. 86.

The Department believes that the extensive experimentation in cloud seeding which has been taken throughout the world has been inconclusive and indefinite. Progress in rainmaking, which potentially has the possibility of developing into a technically sound and respected field of meteorological engineering, has been retarded in recent years by a lack of coordination of the experimental activities carried on by public and private agencies. In addition, a major difficulty has been the limited number of research institutions qualified and equipped to carry out adequate programs of experiments in this field.

We believe that the program envisaged in S. 86, which would center responsibility for the planning and coordination of programs in this area in the National Science Foundation and which would authorize the Foundation to make arrangements for performance of research by qualified private and public institutions, will result in a more expeditious and economical approach to the development of weather-modification techniques. The proposed program would also foster cooperation with private organizations and the States in the development of these meteorological phenomena.

For these reasons, the Department of Commerce recommends enactment of S. 86.

The Bureau of the Budget has advised that it would interpose no objection to the submission of this report to your committee.

Sincerely yours,

SINCLAIR WEEKS,
Secretary of Commerce.

EXECUTIVE OFFICE OF THE PRESIDENT,
BUREAU OF THE BUDGET,
Washington, D. C., March 14, 1958.

Hon. OREN HARRIS,
Chairman, Committee on Interstate and Foreign Commerce,
House of Representatives, Washington, D. C.

My DEAR MR. CHAIRMAN: This is in reply to your letters of August 12 and 16, 1957, requesting the views of this office with respect to S. 86, as it passed the Senate August 6, 1957, and H. R. 9246, identical bills to provide for a research program in the field of weather modification to be conducted by the National Science Foundation, and for other purposes.

These bills would authorize and direct the National Science Foundation to initiate and support a program of study, research, and evaluation in the field of weather modification.

In the reports that they are making to your committee, the National Science Foundation and the Departments of Commerce, Agriculture, Interior, and Defense are recommending favorable action on S. 86 or H. R. 9246.

Although our view is that the National Science Foundation already possesses the necessary authority to carry out basic research needed to advance the field of weather modification, we would not object to enactment of these bills if the Congress believes that they would give a desirable emphasis to the Foundation's work on this subject.

It should be noted that the language in section 3 of the bills which abolishes the Advisory Committee on Weather Control is unnecessary in view of the passage of the Supplemental Appropriation Act, 1958, which provided that this committee "shall complete its report and terminate its activities by December 31, 1957." These events have taken place. We understand, however, that the National Science Foundation would like to have the bills contain language transferring the records of the committee to the Foundation.

Sincerely yours,

PERCIVAL BRUNDAGE, *Director.*

Mr. RHODES. At this time I would like to call on our first witness, a former colleague of ours in the House, the distinguished Senator from South Dakota, the Honorable Francis H. Case.

STATEMENT OF HON. FRANCIS H. CASE, UNITED STATES SENATOR FROM THE STATE OF SOUTH DAKOTA

Senator CASE. Mr. Chairman and members of the committee, I do appreciate the opportunity you have given me to make a statement with reference to S. 86. I also want to express my appreciation of the interest which several House Members have taken. Congressman Hull, whom you mentioned, came over and appeared at our Senate hearings as did Congressman Berry and I believe Congressman Dixon. Those men have taken a definite interest in this legislation. They made effective statements over there before the Senate committee and it is a pleasure to me to see the interest they have taken and to have Congressman Hull's statement inserted as it has been. I hope he can supplement that with personal testimony as Congressman Berry and the others may be able to do too, before you conclude your hearings.

Mr. Chairman and members of the committee, weather is not an accident. I am not a meteorologist nor scientist, but if there is any single sentence of a few words which could suggest to the committee the basic conviction that I have as a layman who simply has listened and read and been interested, it would be bound up in that sentence. Weather is not an accident. In these days when we are trying to find the rules and the laws which govern the universe and beyond that, space, it seems to me it is important to encourage those programs of

research which will enable us to learn more about the things which produce certain effects and then see how that knowledge can be used for the benefit of mankind. There are, of course, a multitude of variables that create weather but it is not a thing of chance. What are the conditions and the variables that make weather or modify it?

Most of the weather phenomena seem to be conditioned by what happens at high altitudes where you have striking variations in temperature and winds with resulting currents and countercurrents. What man is seeking to do is to find out the recipe that produces weather of different character. The space age opens the door of opportunity to know more about the weather.

I am not a meteorologist, nor am I a scientist. I am merely like millions of other people—one who has learned that weather conditions life. The subject is of challenging and compelling interest in these days when we talk about entering the space age.

Mr. Chairman, the bill before your committee, S. 86, authorizes the National Science Foundation to undertake an orderly research program in weather modification.

In conducting its studies, the National Science Foundation would consult with meteorologists and scientists in private life and with agencies of Government interested in or affected by experimental research in weather control.

The Foundation may accomplish the purposes of this act through contracts with private or public institutions, including cooperative programs with the States.

The National Science Foundation is authorized to accept as a gift, money, material, or services and other agencies of the Government are authorized to loan, without reimbursement, property and personnel as may be deemed useful.

The functions, duties, and records of the Advisory Committee on Weather Control are transferred to the National Science Foundation.

I think in effect that has been done. The Advisory Committee concluded its work as of December 31 and has made its report to the President. I believe the National Science Foundation is already acting as custodian of its records. But Dr. Klopsteg can speak more authoritatively on that.

There is authorized to be appropriated to the Foundation such amounts as are necessary to carry out the purposes of this act.

The possible importance of this bill to the Nation and to the world is tremendous. We spend hundreds of millions of dollars to counteract and alleviate weather-caused disasters; or, I might say, to overcome situations created by a lack of knowledge about the weather or what is coming. It is my earnest conviction that what the Congress does to authorize an orderly experimentation and evaluation program in cloud modification will have lasting significance for conditions of drought, floods, hurricanes, hail, lightning, fog, and smog.

What this would mean for the welfare of agriculture, commerce, industry, and national defense is beyond our power to estimate.

Last November, Dr. Edward Teller, in testifying before the Senate Military Preparedness Subcommittee, said:

> Ultimately, we see again and again that small causes in the weather can lead to very big effects, and when that is the case, prediction becomes very hard. But if we find out precisely where the small causes lie, it may trigger off the bigger effects. If we find out that, we will be on the road to controlling weather on a big scale.

Please imagine a world in which the Russians can control weather in a big scale, where they can change the rainfall over Russia, and that—and here I am talking about a very definite situation—that might very well influence the rainfall in our country in an adverse manner. They will say, "We don't care. We are sorry if we hurt you. We are merely trying to do what we need to do in order to let our people live."

What kind of a world will it be where they have this new kind of control, and we do not? I think as you think—that this and other examples totally become very vivid on your mind—what it might mean to become a second-class power.

Dr. Teller's statement needs no comment from me, but it brought a flood of inquiries to my office as to what was happening with the bill your committee is considering today. At this point I would like to go on record as saying that I would not want the public to anticipate phenomenal results at an early date growing out of anything this bill might produce. I think that perhaps the message that the public ought to have is that we feel that man's knowledge is inadequate in this field, that we ought to get more knowledge, that if we could get knowledge that would improve forecasting, the accuracy of it, and perhaps permit longer range forecasting, that those ends of themselves would be worthy objectives. But the potential that we might even get to the position where by learning these variables we could affect the course of weather, over a large area, as well perhaps as in local areas, is so intriguing that we ought not to place limits upon the research projects that the National Science Foundation would engage in.

Personally I think that the National Science Foundation by the quality and character of its leadership and the men who comprise it is the guaranty to the country that the projects would be worthwhile projects. But by the very nature of research there should not be limitations put in. If we knew what the limitations could be we would not need the research to start with. We ought to have a broad program such as this bill proposes.

Mr. Chairman, I have been interested in water projects of one sort or another ever since I have been in Congress, and long before. I first became interested in cloud seeding back in the late forties when I read about experiments then being conducted.

In my section of the country, our crops always depend on the weather, and in the western part of South Dakota we are always concerned with moisture shortages. In 1950, we were badly in need of rain at our ranch. Crops were parched and the stock dam was drying up. I hired a private pilot to take a hundred pounds of dry ice up and seed a cloud. He got a heavy shower—it missed our ranch by 5 miles—but that the cloud he worked on reacted was beyond doubt. Other clouds that looked the same before he worked on this one did not "fuzz" or "bloom" as this one did, nor did they let go of any rain that afternoon. That rain covered a stretch 5 miles wide and about 15 miles long. I then began to take weather modification in earnest.

The Congress first acted favorably on weather modification legislation in 1953 when it passed the bill that created the Advisory Committee on Weather Control. That legislation, S. 285, Public Law 256, was the outgrowth of bills by Senators Anderson of New Mexico, Cordon of Oregon, Butler of Nebraska, Magnuson of Washington, Smathers of Florida, Lehman of New York, Watkins of Utah, Ecton of Montana, Young of North Dakota, Capper of Kansas, O'Mahoney

of Wyoming, and myself over a period of 3 or 4 years. Three Senate committees held joint hearings on the bills introduced at that time and I was asked to work out a residual bill which was S. 285.

The Advisory Committee on Weather Control was directed to study and evaluate public and private experiments in weather modification. The committee was comprised of the Secretaries, or their designees, of the Departments of Agriculture, Commerce, Defense, Interior and Health, Education, and Welfare, and the Director of the National Science Foundation, or his designee. It also included five private members appointed by the President from the fields of science, agriculture, and business. They were: Capt. Howard T. Orville, United States Navy (retired), Baltimore, Md., the Chairman; A. M. Eberle, dean of agriculture, South Dakota State College, vice chairman; Lewis W. Douglas, Southern Arizona Bank & Trust Co., former Director of the Budget and former Ambassador to Great Britain, Tucson, Ariz.; Joseph W. George, brigadier general, United States Air Force Reserve, Atlanta, Ga.; and Kenneth C. Spengler, executive secretary of the American Meteorological Society, Boston, Mass. The Chairman and Vice Chairman were appointed by the President.

The Advisory Committee was not authorized to conduct basic research in weather modification but was directed to make a complete study and evaluation of the experiments being made by public and private groups for the purpose of determining the extent to which the United States should experiment with, engage in, or regulate weather modification activities.

The life of the Advisory Committee on Weather Control expired on December 31, 1957, and the committee made its final report to the President early this year. For the record, I want to say that that committee did a remarkable job—its report is the most valuable single document in the field, I believe. I hope that members of the committee who develop a special interest in this will avail themselves of the opportunity to get their report and examine it.

That report states that in the mountainous areas in Western United States the seeding of winter-type storm clouds produced an average increase in precipitation of 10 to 15 percent with "heavy odds that this increase was not the result of natural variations in the amount of rainfall."

In nonmountainous areas, the results were not as dramatic but the committee report points out that this does not mean that precipitation may not have been produced. The variability of rainfall patterns in the nonmountainous areas made it difficult to evaluate the changes that may have occurred.

I should like to read one short section from the committee report dealing with its recommendations:

> The committee recommends that a research program include work along the following lines:
>
> (1) The effect of solar disturbances on weather.
>
> (2) The factors which control our global atmospheric circulation.
>
> (3) The factors which govern the genesis and movement of large-scale storms.
>
> (4) The dynamics of cloud motions.
>
> (5) The processes of rain and snow formation, and the relative importance of the physical phenomena which govern these processes.
>
> (6) The electrification process in clouds, and the role electricity plays in meteorological phenomena.

(7) The natural sources of condensation and ice-forming nuclei, and their role.
(8) The methods, materials, and equipment employed in weather modification.

The above recommendations, all of which demand basic and fundamental investigations and research, emphasize the meagerness of our present knowledge. These recommendations also reflect the complexity of the problems that must be investigated to provide the basic scientific knowledge that is essential to a technology of weather control.

Therefore, the committee recommends the enactment of S. 86, 85th Congress, which directs the National Science Foundation to initiate, coordinate, and support such a program.

Mr. Chairman, there is a growing interest in weather modification in this country. Until enactment in 1953 of the Federal law which established the Advisory Committee on Weather Control, only a few States had passed laws in the field of weather modification. By the end of 1956, 14 States, Arizona, California, Colorado, Massachusetts, Nevada, New Hampshire, New Mexico, Oklahoma, Oregon, South Dakota, Utah, Wisconsin, and Wyoming, had provided for regulation of weather modification activities in some degree.

My own State of South Dakota explicitly claims sovereign rights to the moisture in the clouds and atmosphere within our State boundaries. I do not know how they would enforce it exactly but you can see our people at least are alert to the situation. Several States provide for research and experimentation by State authorities.

The United States Forest Service is carrying on a research program known as project Skyfire. The purpose of project Skyfire is to develop more effective means of lightning-fire suppression, including the possibility of preventing lightning fires and reducing fire danger through cloud seeding. Lightning is the greatest single cause of forest fires in Western United States. I might say that the man who directs that program for the Forest Service was in Washington recently. He told me that in 29 missions last summer he felt they had positive results in over 20 of those 29.

Mr. Chairman, there are some scientists present who will explain better than I am able to the experiments that have been made in weather modification and the possibilities that have not yet been explored. I shall leave that responsibility in their hands.

I think the members of this committee will be interested in knowing that after the Senate Committee on Interstate and Foreign Commerce had listened to the evidence presented in its hearings on this bill, every member of the committee who was present asked to be listed as a cosponsor of the bill as it was amended and presented to the Senate, and the bill went to the floor with 16 cosponsoring names on it.

Mr. Chairman, we annually spend millions of dollars for drought relief. We spend millions more for flood relief, and beyond that there are untold millions lost in flood and drought damage.

If clouds could be modified so that rain could be produced in time of drought, or clouds dissipated to prevent disastrous floods, the investment of a comparatively small amount of money would be a wise investment. Even the benefits of more accurate and longer-range forecasting offer tremendous returns for efforts expended even though we did not have the possibility of modifying the weather in any particular.

Water is America's No. 1 problem. Our water use has more than doubled since the turn of the century. Annually we spend millions

of dollars trying to discover new water sources and to better utilize those that we already have, while in the sky there is a reservoir of uncounted billions of gallons of sweet, fresh, clear water. It seems to me that we ought to provide the experimentation program so that this generation and those following can successfully tap that source of supply.

Mr. Chairman, may I conclude by repeating my opening sentence: Weather is not an accident. It conditions all life. Let us learn what we can about it. Thank you, Mr. Chairman.

Mr. RHODES. Thank you very much, Senator Case. We appreciate your very informative statement. Are there any questions?

Mr. O'BRIEN. I join the chairman in congratulating Senator Case on a very fine statement. You developed very fully the fact that we cannot afford not to have this research.

I wonder, do you think it is reasonable to assume that the Russians at the present time are making intensive and extensive studies in this particular field?

Senator CASE. I think it is reasonable to assume they are making studies in the field, but I have no personal knowledge of what they may be doing. I think Dr. Teller's statement rather startled the Preparedness Subcommittee at the time he made it. I was present at the time. Different Senators at the time directed some inquiry to him. Senator Johnson, Senator Smith of Maine, Senator Flanders all commented upon it. But it was an open session, and if Dr. Teller had any specific knowledge he did not disclose it. He did say, of course, what was quoted here. I have no knowledge of it. I think the reasonable assumption or the safe assumption is that with the great emphasis the Russians are placing upon science and upon the things that might improve their agriculture and improve their general situation, they would take steps to learn what they could in this field.

Mr. O'BRIEN. I was startled by your quotation from that testimony, too. I agree 100 percent with you that we must assume that the Russians are doing many things that we have no specific knowledge of and not make the mistake in this field as we have in some others of underestimating their scientific capacity.

Senator CASE. Might I supplement what I said. It is interesting that the Russians should be working in this field because so much of our weather seems to come from the northwest. I know in my area, I am speaking solely from personal experience, in my area the weather we get in southwestern South Dakota one day is somewhat forecast by what is to the northwest of us 18 to 24 hours before that. I believe the prevailing winds and currents of air are such that weather in Alaska or to the west of that moves on to the south and southeast many times.

So that if they should be experimenting or even if they should be learning something about the course of weather, whether you modify it or not, if they are learning something about it, they would have the advantage of forecasting what our weather would be if it is traveling in our direction. To that extent we ought to improve our techniques in getting earlier forecasts as well.

Mr. RHODES. Dr. Neal?

Mr. NEAL. Mr. Chairman, I have no questions. I certainly appreciate the fact that the Senator has presented to us a very, very important and far-reaching problem. Most certainly anything that aids us in determining more about weather conditions, how they can be improved upon, anticipated, more or less controlled, will mean a great deal to this country.

I appreciate the statement you have made. You covered it very well.

Mr. RHODES. I would like to welcome at this time Prof. Charles Raith, with a group of his students from Albright College, Reading, Pa. They are visiting Washington to observe our Government in action, attending committee hearings, sessions of the House and Senate, and touring executive departments. We are pleased to have them with us.

Mr. O'BRIEN. Mr. Chairman, I think one of the great tragedies at this time of the year is to see so many young people come to Washington, watch the 2 Houses in session, and somehow not find the time to go to some of the committee hearings where 90 percent of the laws are really constructed. I think it is a wonderful thing that these young people are here today and I hope many thousands in the next few weeks will find an opportunity to attend committee meetings.

Mr. RHODES. Thank you, Mr. O'Brien.

Mr. DINGELL. I would like to also join with you in welcoming these young people and hope that their visit here will be fruitful. I am sure they can see their very able Congressman, my distinguished friend, Hon. George Rhodes, is presiding over a meeting of a subcommittee of the House Committee on Interstate and Foreign Commerce. I think each of these young people might like to know the jurisdiction of our committee extends over almost everything that moves in this country, when it moves across State lines or affects something which does move across State lines.

Not only are we interested in this committee in railroads and radio and television, pipelines, natural gas, advertising, aviation, but we are also interested in legislation. I think you can see that your very fine Representative, my good friend, Hon. George Rhodes of Pennsylvania, is continuing his interest not only in those things that specifically affect his own district but in matters which affect the country.

I would like to conclude by saying that I hope your visit here will be both enjoyable and educational. I would like to compliment you for having come down here and having expressed your interest in government and hope that if something I may do to make your visit more pleasant comes about, that you will permit me to help your very fine and very distinguished Congressman, George Rhodes, of whom I happen to be very proud. Thank you.

Mr. RHODES. Thank you very much, Mr. Dingell.

Are there further questions?

Mr. LOSER. I would only add this to what has been said by my colleague. It is directed to our visitors this morning from Mr. Rhodes' district. This subcommittee is holding a hearing in an effort to develop a research program in the field of weather modification and our first witness this morning is a very distinguished Member of the United States Senate, Hon. Francis Case from South Dakota. I am happy to have been privileged to hear you explain your bill, Senator. Thank you so much.

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Mr. RHODES. Anything further?

Mr. DINGELL. I want to compliment the very distinguished Senator from South Dakota for his fine presentation this morning and also for the work he did in getting this bill through the Senate. I would like to extend my most warm and cordial welcome to him.

Senator CASE. Thank you very much. I appreciate what all the members of the committee have said in their kind words and their questioning.

I would like to paraphrase what Congressman Dingell has just said. I will appreciate your help in getting it through the House but I also want to thank you for the help which House Members gave us in getting this bill through the Senate. It is the type of legislation which initially does not seem of earth shaking importance. It does not have an immediate crisis ahead of it. But in its total implications I doubt if there is any legislation that will be considered in this session of Congress that has greater potentialities and I certainly appreciate the interest each of the members of the committee has shown by being here this morning and the interest you have taken in your questions and the attentive hearing you have given me.

Mr. RHODES. Thank you very much, Senator Case.

Our next witness will be Congressman E. Y. Berry of South Dakota. Mr. Berry is the sponsor of H. R. 5430.

STATEMENT OF HON. E. Y. BERRY, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF SOUTH DAKOTA

Mr. BERRY. Thank you, Mr. Chairman. I appreciate this opportunity of appearing before this committee. I appreciate the early action of this committee in hearings on S. 86 and on similar House bills among which is my bill, H. R. 5230. I think this is, as Senator Case has said and as members of this subcommittee have indicated, one of the important pieces of legislation that will come before Congress at this session. There has been generated in this country almost a hysterical desire to control outer space, yet the control of the atmosphere is probably many times more important than is outer space. This bill provides a means by which we can develop a control of the atmosphere. The bill provides that basic research be established under the National Science Foundation and it would be my recommendation that a weather commission composed of both scientists and laymen be set up to correlate information already obtained and to move forward under contracts with private industrial groups who have already spent millions of dollars of private money in research; with Government agencies, with State agencies, and with colleges and universities, in the rapid development and research of the various phases of weather modification, of hail suppression, of lightning suppression, of rain and snow increase, and so forth.

I strongly urge that funds appropriated for this purpose be made available through contract, through all of these agencies under the direction of the Commission, responsible to the National Science Foundation who will push forward a weather modification program at the fastest possible rate.

America has already demonstrated what can be accomplished in the race for space when we set our minds and efforts toward that goal.

Let us through this legislation establish the machinery for a similar program to learn how to control the atmosphere which is equally important for both military and economic purposes.

Private enterprise has already spent millions of dollars and has made vast gains in basic research. This bill would provide a coordinating Government agency which is seriously needed. It is long past due, and I trust that this committee will perfect this legislation and report it as early as possible.

I ask unanimous consent at this time to insert in the record the statement of Josiah Ferris, of the American Sugar Cane League of the United States, who is unable to be here and who has mailed to me his statement endorsing, if you please, the testimony that will be given by John S. DiSanto, field director for water resources development, a little later in the hearings.

Mr. RHODES. Thank you, Mr. Berry, for your excellent statement. Without objection, the statement of Mr. Ferris will be inserted in the record.

(The statement of Mr. Josiah Ferris follows:)

STATEMENT OF JOSIAH FERRIS, VICE PRESIDENT, THE AMERICAN SUGAR CANE LEAGUE OF THE UNITED STATES OF AMERICA, INC.

My name is Josiah Ferris. My address is 510 Union Trust Building, Washington, D. C. I am a vice president and manager of the Washington office of the American Sugar Cane League of the United States of America, Inc.

The American Sugar Cane League is a nonprofit corporation domiciled in the State of Louisiana. Its membership consists of more than 7,000 Louisiana sugarcane farmers, who produce approximately 98 percent of the sugarcane grown in the State of Louisiana, and of all of the Louisiana processors of sugarcane into sugar. I appear at this hearing on behalf of that organization and its members.

Sugarcane is the only cash crop on the vast majority of these 7,000 Louisiana farms, and there is no satisfactory cash farm enterprise that can be substituted for sugarcane.

The Louisiana producers of sugarcane and processors of sugarcane into sugar are definitely interested in the ultimate enactment of Senate bill No. 86 which relates to weather modification. Rainfall and moisture is a limiting factor in sugarcane yields in the State of Louisiana practically every year. While it is true the average annual rainfall in the Louisiana sugarcane area is approximately 60 inches, our rains do not usually come throughout the growing season, and each year, with few exception, the growth of the cane is adversely affected by one or more periods with little or no rainfall.

The normal cane growing season in Louisiana is the period from April through October, and the peak growing period is from June through September. During much of the peak growing period, if there is adequate moisture the sugarcane will grow approximately 1 inch each day. In the absence of moisture or adequate moisture, this growth is seriously retarded. Therefore, it is obvious the demand for moisture in the Louisiana sugarcane area during the peak growing period is constant and substantial.

In considering Senate bill 86 in relationship to sugar, it should be borne in mind that sugar, which is produced from sugar cane and sugar beets, is not a surplus crop in the United States. Only 30 percent of the Nation's requirements are produced on the mainland of the United States and only 55 percent of the Nation's requirements are produced in all domestic areas including Hawaii, Puerto Rico, and the Virgin Islands. Approximately 45 percent of our sugar requirements are met by sugar imported from foreign countries.

In view of the facts which I have briefly and generally stated, the American Sugar Cane League and the Louisiana sugar cane farmers and processors are naturally and vitally interested in any properly directed research that might eventually lead to a practical method of obtaining additional rainfall when needed.

We endorse the suggestions made by Mr. John L. DiSanto, field director, Water Resources Development Corp., 460 South Broadway, Denver, Colo., in his testimony on this bill. Those suggestions are:

1. The scope of research should be defined to include basic, applied, and engineering research.

2. The National Science Foundation should be required to establish a Committee on Weather Control composed of 6 scientific members and 5 lay members. None of these committee members shall represent a Government agency or a commercial operator.

3. The various Government agencies concerned with this program shall be designated as technical advisors to the Committee for Weather Control.

4. The commercial operators shall also be designated as technical advisors to the Committee on Weather Control.

5. The Committee on Weather Control shall be responsible for the coordination of all research activities.

6. The bill should provide a method of giving financial assistance to organized groups of farmers, industrial organizations, municipalities and others who have been or are now conducting scientific weather modification activities.

7. The National Science Foundation and its Committee on Weather Control shall be instructed to utilize the knowledge, skill and experience of the private operators in the development and conduct of such research.

We respectfully urge a favorable report of this committee.

Mr. BERRY. I have a number of letters and telegrams from people all over the United States. While I would like to have them made a part of the file, they are too bulky for the record. I would like to ask unanimous consent to read a paragraph or part of a paragraph from these letters, as I identify them.

Mr. RHODES. Very well.

Mr. BERRY. This letter is from William Raabe, chairman of the South Dakota Weather Modification Commission, of Tyndall, S. Dak. Part of his letter is as follows:

If the National Science Foundation receives the funds we should have a joint committee of scientists and laymen to administer the program.

The members of this committee should be nongovernmental people so the program keeps moving.

Both Government agency representatives and private operators may serve as technical assistants.

There is also a letter from Charles Hughes of Denver, Colo., in which he says:

It is inconceivable to me, during a period of national economic concern, that the Government should elect to duplicate and compete with those private corporations and citizens who have the courage and energy to help themselves.

He also encloses a letter to Senator Bible.

From Fairfax, Mo., Pharon Nauman, of Fairfax, says, among other things:

I believe there should be a committee of scientists and laymen to administer this program and have a voice in the control of the funds.

There is a letter from Thomas M. Dines, Colorado Springs, Colo., from which I quote in part:

As a taxpayer I am convinced that our dollars will go further if they are entrusted to those organizations which have had the foresight, the conviction, and the courage to bring this new field of applied science to its present state of being, and in the process have amassed a wealth of background information and know-how which would be most valuable.

There is one from the N. D. Bard Agency, of Stanfield, Oreg., expressing about the same concern and urging passage of S. 86.

There is also a letter from Morrison B. Cunningham, director of public works of the city of Oklahoma City, Okla., urging the same thing.

Truman E. Pease, St. Marys Kraft Corp., St. Marys, Ga., also urges passage of the bill.

I quote from the letter of Vernon Taylor, Jr., Peerless Oil & Gas Co., Denver, Colo.:

> This company has for a number of years used the services of Dr. Irving Krick and have found these services most helpful and have on occasion saved us substantial sums of money.

Roscoe Ozman, Amherst, Colo., encloses a report of the Dallas Water Service.

There is also a letter from Stanley Wallbank, of Denver, Colo.

I have telegrams, received yesterday and today, from several people. James M. Wolf, president of the Cornhusker Weather Modification Association, of Albion, Nebr., urges passage. O. C. Swackhamer, president of the Iowa-Missouri Weather Modification Corp. also sent a telegram in support of S. 86. Walter Myers, executive director of the Forest Farmers Association sent a telegram which reads in part as follows:

> The Forest Farmers Association representing owners of 25 million acres of timberland in 15 Southern States wants to express its continued interest and endorsement of S. 86.

There is a telegram from the committee for Morrow County, Oreg., Weather Research, Inc., endorses S. 86. One from the Sacramento River Weather Association, David J. Elliott, president, Sacramento, Calif., says in part:

> Sacramento River Weather Association, representing 80 bartlett pear growers producing 90 percent of total district tonnage, urge you to support and approve passage of Senate bill 86—

and so forth.

These, I believe, Mr. Chairman, give an idea of the support from all over the United States of people in all walks of life in the passage of S. 86. I thank you.

Mr. RHODES. Thank you, Mr. Berry. The notations will be included in the record.

Are there any questions?

Mr. O'BRIEN. I have had the pleasure of serving on another committee with Mr. Berry for a number of years. His sponsorship of any legislation carries a great deal of weight.

As I understand it, Mr. Berry, this particular legislation would limit the National Science Foundation to study, research, and evaluation and not permit any great project other than a project for study and research and evaluation.

Mr. BERRY. Yes; that is true.

Mr. O'BRIEN. Until we get this information which would flow from these studies and evaluations, Congress could not legislate objectively and constructively in that field. Is that your thinking?

Mr. BERRY. I thought that possibly the bill could be amended to provide that a commission operating under the National Resources Commission, composed of laymen and scientists together, could be established with authority to contract with the existing companies who have been in this business to further promote this program, using their information, making their information available to the Government as well as the Government making their information available to the private companies.

There are several of these companies that have spent vast sums of money in experimental work already. It seems that to get the greatest benefit, the benefit of their knowledge should be made available.

Mr. O'BRIEN. Would that not be accomplished by this bill as it is now written?

Mr. BERRY. It could be, I think.

Mr. O'BRIEN (reading):

Research programs to carry out the purposes of this act by the National Science Foundation, and by other Government agencies or departments, may be accomplished through contract with, or grants to, private or public institutions or agencies, including but not limited to cooperative programs with any State through such instrumentalities as may be designated by the governor of such State.

Mr. BERRY. It could be. The only thing would be to make sure that private companies were included.

Mr. O'BRIEN. Thank you.

Mr. RHODES. Are there any further questions?

Thank you very much, Mr. Berry.

Mr. BERRY. Thank you.

Mr. RHODES. Is Congressman Baring here? We are glad to have as our next witness, the Honorable Henry A. Dixon, our colleague in the House, a Representative from Utah, who is sponsor of H. R. 9246.

STATEMENT OF HON. HENRY ALDOUS DIXON, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF UTAH

Mr. DIXON. Mr. Chairman and gentlemen of the committee, first of all I thank you as an old schoolteacher for the welcome you have given these young people. I would like to say as George Bernard Shaw said, "Youth is such a wonderful thing. It is a pity to waste it on the young." I can hardly agree with him when I look into your faces. I think your presence here refutes pretty much the philosophy of that old cynic. As much as I regard him, I certainly do not want to depreciate his great service, I wish that the young people whom I have taught could be closer to this great committee and see what it is doing.

You young people might think that those of us who have introduced bills here about controlling the weather are nuts. I was just talking with 1 or 2 men down here. I said, "Do you think that you have to be nuts to advocate legislation to control the weather?" Mr. Quate over here says, "No, you do not have to be, but it helps."

On February 3, 1958, I met at the White House with a few interested Congressmen and members of the Advisory Committee on Weather Control—and I am pleased to see so many members of the committee here today who were at the formal presentation of their final report to the President. I came away from this meeting more convinced than ever of the urgent need for an expanded, sustained, fundamental research program in weather control. The following are some of my reasons. First, we have definitely made progress in weather control. About 10 years ago 2 scientists, including Nobel prizewinner Dr. Irving Langmuir, succeeded in creating a snowstorm by dropping dry ice pellets from an aircraft into a supercooled cumulus cloud.

For the benefit of these young people, too, I would like to say that sometimes you almost believe in the spiritual control of history. Here we have Senator Case who hired a pilot to go up in an airplane and drop some crystals that brought about a rainstorm. But the rainstorm went on his neighbor's farm rather than on his own. That created an impression and this wonderful Senator now is promoting this legislation. I sometimes think that acts like this are really providential. I certainly praise the great Senator in your presence, young people, for leading out in this cause.

I favor S. 86 or H. R. 9246. First, because we have definitely made progress in weather control as a result of 5 or 6 years of exhaustive research at Mount Washington, N. H., and by General Electric representatives at Schenectady, N. Y. Since then there has been a spate of rainmakers. Some of them made fantastic claims, with little scientific knowledge of weather modification. Since weather control offered promise but had also proved disappointing to many farmers who had paid for cloud seeding, the Advisory Committee on Weather Control was established to study weather modification without preconceived notions. I would like to quote a summary of the findings of this venerable committee. I found in the preface of the volume, volume I of their final report, this summary.

Mr. Chairman, I ask unanimous consent to have this summary of these findings inserted in the record.

Mr. RHODES. Very well. Without objection, they will be included.

(The summary referred to follows:)

A. On the basis of its statistical evaluation of wintertime cloud seeding, using silver iodide as the seeding agent, the committee concluded that:

(1) The statistical procedures employed indicated that the seeding of winter-type storm clouds in mountainous areas in Western United States produced an average increase in precipitation of 10 to 15 percent from seeded storms with heavy odds that this increase was not the result of natural variations in the amount of rainfall.

(2) In nonmountainous areas, the same statistical procedures did not detect any increase in precipitation that could be attributed to cloud seeding. This does not mean that effects may not have been produced. The greater variability of rainfall patterns in nonmountainous areas made the techniques less sensitive for picking up small changes which might have occurred there than when applied to the mountainous regions.

(3) No evidence was found in the evaluation of any project which was intended to increase precipitation that cloud seeding has produced a detectable negative effect on precipitation.

(4) Available hail frequency data were completely inadequate for evaluation purposes and no conclusions as to the effectiveness of hail suppression projects could be reached.

B. On the basis of its physical evaluation, the committee concluded that:

(1) The conventional seeding with silver iodide generators on the ground is a valid technique for producing ice crystals in favorable summer and winter storm situations. (Formation of ice crystals is thought to be essential for the initiation of precipitation from most cold clouds. However, it is relevant to observe that precipitation does not necessarily follow.)

(*a*) Measurements of silver iodide particle concentrations at points several miles distant from the generators were compared with the estimated concentrations there. On the basis of the limited tests made, it was found that the rate of deactivation was low enough to be of no great concern for practical seeding, even during the adverse decay conditions of bright sunlight and warm temperatures.

(*b*) Silver iodide particles in sufficient concentrations to produce seeding effects were found at distances up to 30 miles from the ground generators in particular tests.

(2) Measurements and cloud observations in various regions throughout the United States have indicated that sometimes there is a deficiency of natural ice

forming particles effective at the temperatures at which ice crystals are formed on silver iodide.

We are fortified in the conclusion that significant progress has been made in weather modification by a statement of the American Meteorological Society on April 30, 1957:

1. The seeding of a supercooled cloud with dry ice will usually convert at least a portion of the cloud to ice crystals. Under appropriate conditions, such seeding may release variable amounts of precipitation * * *.

2. The injection of water drops or hydroscopic salt particles into active, warm (nonsupercooled) cumulus clouds may release some rain * * *.

3. In some cases warm fog and stratus may be dissipated in restricted regions by the use of certain hygroscopic materials.

4. At temperatures below about —5° centigrade silver iodide crystals are known to affect supercooled clouds in much the same way as dry ice * * *.

5. Cloud seeding acts only to trigger the release of precipitation from existing clouds * * *.

6. No convincing evidence has been presented which indicates that ground-based silver iodide seeding affects the amount or character of precipitation over flat country. (Mountain country is different.)

7. * * *.

8. * * *.

9. All cloud-seeding operations should be considered as experiments since the techniques are still under development and there is no sound basis for the quantitative estimation of the results in advance of the operation * * *. There is good reason to believe that improved returns from cloud seeding will result from a sound experimental approach and this should be fostered by all concerned.

President Eisenhower has shown personal interest in weather control and on July 18, 1957, he wrote Captain Orville, chairman, Advisory Committee on Weather Control:

Of particular interest was your indication of the probability that, at least along the western coasts, increased precipitation might be expected from cloud-seeding operations. I can readily appreciate the importance such production of additional water supplies might have in helping to ease the Nation's emerging problem of growing scarcity of water resources in many areas.

Mr. DIXON. My second reason for favoring these bills is that droughts incur terrible hardship and should be modified if possible. In Utah we hardly have a spear of grass grow that is not irrigated. Of course, that is not true above six- or seven-thousand-foot level in the mountains, where we have considerable precipitation. We have had terrible droughts there, so extended and long that one of my farm constituents from a Scandinavian country told me, that was 2 years ago, we had not had a normal year of precipitation in 40 years. I do not know where he gets his statistics from, but he really felt what he said.

You can see why I am interested in this weather modification.

One of the deepest impressions of my life has been to visit the 25 counties of my district during the congressional recess, especially during 1955, and see the despair written on the faces of so many of our fine, industrious Utah farmers. This drought, which was probably the greatest in American history, not only produced human misery but was a great economic loss to the Nation. For example, the amount of emergency credit given by the Farmers' Home Administration for the 4½-year period ending December 30, 1957, amounted to $318 million. The emergency feed program, which also operated in serious drought areas, cost $221 million. The hay and roughage program cost an additional $35 million. The Federal Government also spent $184 million to bolster livestock prices during a recent 3-year period primarily required because of the drought.

There was no forage on the winter range. Our farmers had raised very little feed on their farms in the summer and were short of feed for their livestock over the winter. This caused them to push their

livestock onto the market all at once, which depressed the market terrifically. That is why the Government had to support livestock to some extent.

The emergency CAP payments for land damaged by wind erosion primarily due to drought cost $17,956,000. The emergency food distribution programs of the USDA, a significant share of which was for drought, amounted to $156,254,376.

These costs to the taxpayer are only a minute fraction of the billions of dollars of economic loss to the farmers and other citizens of the drought-stricken States. The estimate has been made that nearly 29 million acres of land in the Great Plains States are conditioned to blow away for lack of protective plant cover.

Third, weather control can help reduce other types of damage. Drought is not the only hardship of unstable weather, because enormous damage is also produced by hailstorms, hurricanes, and forest fires caused by lightning. Approximately 70 percent of forest fires, with their costly damage to our timber resources and watersheds, is caused by lightning.

Not long ago I was favored by a visit from Mr. Barrows, of the Forest Service from Idaho, close to McCall out of which place the Forest Service operates the smoke jumping program. I visited these centers, have been out in the primitive area and have watched these boys (the smoke jumpers) jump from airplanes at the risk of their lives to stop fires. I have seen them on fires 25 minutes after the sentinels on the high peaks have given them the alarm.

I know of the cost, the dangers, and the damage of forest fires. Mr. Barrows told me that out of about 29 experiments, 19 or 20 had been definitely positive. What a boon to our timber areas and all of our forests and Federal domain if we can catch clouds before they gather enough to cause electrical storms. Mr. Barrows is quite sure we can stop the source of 70 percent of all of our forest fires. That alone, Mr. Chairman, would justify, in my opinion, many, many times the money that S. 86 and our House bills could call for.

In the fourth place, we need this legislation and appropriation because we must beat Russia to the punch.

H. G. Wells once wrote:

> Human history becomes more and more a race between education and catastrophe.

Dr. Edward Teller, who was quoted by Senator Case, stated that if the present trend continues in 10 years the best scientists in the world will be Russian. This would be a disaster for freedom and human feelings.

America could become as subject to Russia's whims as a rat in a laboratory to an experimenter. If Russia beats us to the punch on learning how to control the natural laws governing weather changes, she could conceivably produce a drought over our whole continent or a disastrous flood. We know that the Russians are devoting great energy and scientific talent to learning how to control the weather. It is urgent that the United States not fall behind in his race.

There are many calls upon Congress for projects to meet the needs of the post-sputnik world. We must evaluate the prospective benefit as well as the cost of each proposal. In the problem of weather control, I believe the stakes are enormous and the cost is relatively minor.

Consequently, this should have high priority in our changing pattern of scientific research. Furthermore, basic research over a long and extended period of time is necessary for purposes of comparison in weather modification. So it is urgent that Congress pass H. R. 9246 or S. 86 to pave the way for a permanent, substantial weather research program conducted by the National Science Foundation in cooperation with other agencies.

Mr. RHODES. Thank you, Mr. Dixon.

Any questions?

Mr. NEAL. Mr. Dixon, inasmuch as the terms and provisions of the Senate measure are practically the same as yours, you have no objection to the adoption of the Senate measure?

Mr. DIXON. None whatever. I should like very much to see our Senator Case get credit for this.

Mr. RHODES. The next witness is our colleague from Missouri, Hon. W. R. Hull, Jr.

STATEMENT OF HON. W. R. HULL, JR., A REPRESENTATIVE IN CONGRESS FROM THE STATE OF MISSOURI

Mr. HULL. I appreciate the opportunity of presenting to the Subcommittee on Health and Science of the Committee on Interstate and Foreign Commerce my views on S. 86 and H. R. 3631, providing generally for a research program in the field of weather modification.

On January 24, 1957, I introduced H. R. 3631 providing that for a period of 5 years following the effective date of the act, the Advisory Committee on Weather Control be authorized and directed to formulate a program of experimental research in the field of cloud modification with special reference to areas that have suffered from shortage of natural rainfall.

The Advisory Committee on Weather Control was established by act of Congress in 1953. It passed out of existence December 31, 1957, and on that date submitted its final report to the President of the United States.

I agree with the various recommendations submitted by the Advisory Committee on Weather Control in its final report, including the recommendations that the National Science Foundation be authorized to initiate and support a program of study, research, and evaluation in the field of weather modification and that S. 86, incorporating authority for this program, be enacted by the Congress.

I ask that my bill, H. R. 3631, be amended to incorporate the language of S. 86 and recommend that this amended bill be passed by the Congress.

Mr. RHODES. Thank you for your testimony, Mr. Hull.

Mr. HULL. Thank you, Mr. Chairman.

Mr. RHODES. The next witness is our colleague from Nevada, Hon. Walter S. Baring.

STATEMENT BY HON. WALTER S. BARING, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEVADA

Mr. BARING. Mr. Chairman, on March 21, 1957, I addressed a letter to the special subcommittee of the Senate Interstate and Foreign Com-

merce Committee on the subject of cloud seeding and weather modification activities conducted in northern Nevada, during the years 1951 through 1956 without Federal assistance. In that letter, I pointed out a need for a scientifically designed and organized program of seeding over a long enough period of time so that the resulting data could be properly evaluated in the interests of both the local participants and the general public. I should like at this time to read that letter to this committee, and to make it a permanent part of the record of these hearings:

"Last month, I received a letter from George G. Moseley, secretary-treasurer, Pershing County Water Conservation District of Nevada, directing my attention to the efforts of Mr. Edmund Muth, Assistant State engineer, and chairman of the Nevada State Cloud Seeding Committee, toward the development of a cloud seeding and weather modification program in northern Nevada.

"Upon receipt of this letter, I immediately established contact with Jack C. Oppenheimer, executive secretary, Advisory Committee on Weather Control. Through him I learned that tests were made in Nevada, under the direction of the Nevada State Cloud Seeding Committee, by the Water Resources Development Corporation of California, and by the North American Weather Consultants, as follows:

"May 1 through July of 1951, in Elko County.

"September 1951 to March 1952, in Elko County.

"December 1, 1954, to June 1, 1955, in White Pine, Lincoln, and Nye Counties.

"November 1, 1955, to May 30, 1956, in drainage area above Owyhee Dam and in the following counties: Humboldt, Pershing, Elko, Lander, and Eureka.

"In addition, John Drackert, formerly manager of Pyramid Lake Guest Ranch in Sutcliffe, Nev., performed several tests.

"These sporadic cloud-seeding operations indicate a need for a scientifically designed and organized program of seeding over a long enough period of time so that the resulting data can be properly evaluated in the interests of both the local participants and the general public.

"The Advisory Committee on Weather Control favors the principles contained in S. 86, introduced by Senator Francis Case of South Dakota, and as they would administer the program, if the bill is enacted, they have expressed an interest in northern Nevada, which is a normal irrigation area, as an area which would provide data of scientific value. Accordingly, I have introduced H. R. 5954 as a companion bill to S. 86, and I feel that the proposed program would definitely benefit Nevada, as well as other Western States."

Under previously appropriated programs, the Advisory Committee on Weather Control established that cloud seeding operations on the western slopes of the Pacific Coast States during the cooler and moist winter and spring months, have increased precipitation some 15 percent over that which would normally be expected. These conclusions are quite significant, but as yet they cannot be applied to other areas. Different climatic and topographical conditions that characterize experimental areas in northern Nevada, and other inland mountain areas, produce certain physical problems that will require additional tests.

I understand that successful cloud seeding requires clouds which extend above the freezing level. The problem is to get the silver

iodide smoke particles from the ground base generators up to these high levels where they will be effective, without the aid of airlifting slopes. Previous tests were successfully accomplished on the western mountain slopes only with this natural assistance. The Advisory Committee, I am also informed, cooperated with the United States Forest Service in a program of research and evaluation in cloud seeding to diminish or suppress lightning. To the extent that this program was successful, the results may be applied to hail suppression operations, since conditions which produce lightning are similar to those which produce hail. A study of tests made in Switzerland indicates that hail frequency has been reduced in those target areas. I have seen extensive destruction caused by hail throughout Nevada.

I do not believe that any weather modification program took place in Nevada during 1957, and even though the law which established the Advisory Committee on Weather Control, which was liquidated on December 31, 1957, provided that all experimental work, either private or Government, be reported to the former Committee for proper evaluation and cataloging, the sporadic cloud-seeding operations heretofore conducted in Nevada have not provided conclusive scientific information. The Pershing County Weather Conservation District of Nevada has requested that northern Nevada, which comprises Pershing, Humboldt, Lander, Eureka, and Elko Counties, be included in such a program as is encompassed in S. 86, as amended, and since the conclusions and tentative observations resulting from western-State tests cannot yet be applied to inland areas without further basic and applied research and experimentation of the kind envisioned by S. 86, as amended. I urge that my bill, H. R. 5954, which has also been amended to conform to the provisions of S. 86, as amended, be reported favorably.

The amendment above referred to would merely transfer from the defunct Advisory Committee on Weather Control to the National Science Foundation, an existing organization, authorization to initiate and support a program of study and research in the field of weather evaluation.

I appreciate the opportunity to appear before this committee.

Thank you.

Mr. RHODES. We appreciate your testimony, Mr. Baring.

Mr. BARING. Thank you, Mr. Chairman.

Mr. RHODES. The next witness is our colleague from Florida, Hon. Paul G. Rogers.

STATEMENT OF HON. PAUL G. ROGERS, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF FLORIDA

Mr. ROGERS. Mr. Chairman, thank you for this opportunity to voice my support of this bill, S. 86.

All sections of the country are vitally effected by the ravages of bad weather, and especially from the effects of drought, flood, hail, and tornadoes. Legislation of this type will add to the understanding of weather, its improved forecast, and eventual modification.

As in the rest of the Nation, Florida people depend on good weather and good weather forecasting. The effects of tropical hurricanes and floods are a constant threat to lives, crops, and industry.

The national hurricane research project, established in 1956 has contributed and continues to contribute much needed information in the field of hurricane development and forecasting. This bill now under consideration, S. 86, will broaden the field of weather investigation and modification, and should be of great benefit not only to farm and industry, but to every man, woman, and child in the country.

In addition to these important factors to the public, the Nation's defense effort will also benefit from this new legislation. Such weather research and modification can be of great help to the defense of this country, and may prove in the future to be absolutely vital in this regard.

The National Science Foundation may be aided under this bill by other Government departments, and with their help conduct experimental research in the field of weather control. Perhaps we are at last reaching the day when someone will actually be able to "do something about the weather." As that day approaches, it is clear that the United States should not be left behind in this field, from the standpoint of national defense.

Every American looks forward to the day when the farmer, industrialist, businessman, and worker might plan his work and play with the weather working for him, instead of against him. In everyday life, improved weather forecasting, and eventual weather modification and control would be a great blessing to all.

This bill, S. 86, will be a big step in the right direction, and establish a sound program for the betterment of all our people.

It is a pleasure to join the many supporters of this legislation and I certainly hope for its speedy adoption by this committee, and the Congress.

Mr. RHODES. Thank you, Mr. Rogers.

Mr. ROGERS. Thank you, Mr. Chairman.

Mr. RHODES. The next witness was to have been Dr. Waterman, Director of the National Science Foundation, but I believe we have a substitute.

Mr. KLOPSTEG. That is right.

I am the Associate Director (Research) of the National Science Foundation and because of Dr. Waterman's unavoidable absence, he asked me to appear in his stead.

Mr. RHODES. Please continue.

STATEMENTS OF DR. PAUL KLOPSTEG, ASSOCIATE DIRECTOR (RESEARCH), NATIONAL SCIENCE FOUNDATION; AND WILLIAM HOFF, GENERAL COUNSEL, NATIONAL SCIENCE FOUNDATION

Mr. KLOPSTEG. Mr. Chairman and members of the committee, I would like to read for the record a statement which Dr. Waterman had prepared for presentation before your committee.

(The statement follows:)

STATEMENT OF ALAN T. WATERMAN, DIRECTOR, NATIONAL SCIENCE FOUNDATION, RE S. 86, A BILL TO PROVIDE FOR RESEARCH IN WEATHER MODIFICATION

Mr. Chairman and members of the committee, I am very happy to set forth my views on S. 86, a bill to provide for a research program in the field of weather modification to be conducted by the National Science Foundation, and for other purposes. This bill calls upon the National Science Foundation to initiate and

support a program of study, research, and evaluation in the field of weather modification. The Foundation would be expected to initiate and support basic scientific research and evaluation programs in the general area of weather modification, particularly through intensified work in the fields of cloud physics and other pertinent areas of meteorology. The bill would also contemplate that, where appropriate and desirable, applied research and development work in weather modification be undertaken.

I am familiar with the problems involved, not only as Director of the National Science Foundation but also from having been a member of the Advisory Committee on Weather Control. From the evaluation activities of the Advisory Committee, evidence to date seems clearly to indicate that no large rain-producing effects will be achieved by present means without further basic research to acquire a much fuller understanding of the processes by which nature produces rain or snow. Ability to modify weather, including control of precipitation, presupposes accurate knowledge of what would happen at a predetermined time if we did not attempt modification. The word "modify" means "change"—changing something that we know in advance would happen naturally. Clearly better understanding is also needed for accurate prediction.

It is my view, both from the studies of the Committee and from consideration given to the subject in the Foundation, that by far the most important element toward effective progress in weather modification at this time lies in a planned program in support of research by competent scientists on the fundamental problems dealing with the precipitation process. In this connection, it is important that the interest of more competent scientists be attracted to careers in meteorological research. At the present time, there are an insufficient number of research scientists in this country working in the field of meteorology. Such studies should be conducted under controlled laboratory conditions and also by carefully planned field experiments. The latter may consist of studies of the conditions under which precipitation occurs naturally and also of studies to determine the factors involved in the results of manmade attempts to duplicate or augment natural processes. Plans for the latter type of field experiment should include authoritative means for statistical analysis and evaluation, a difficult task.

In order to achieve maximum effect in causing or promoting the condensation of water vapor into rain or snow, scientists are generally agreed as to the fundamental requirements to be met since what man can do is almost insignificant compared to the massive scale on which nature operates. The most promising attempt would be to locate some critical point and time where nature's forces are in critical balance and undecided, so to speak, whether to produce rain or not. Then the small nudge which man may make might swing the balance his way. Another general method is to try to devise a chain reaction which will propagate itself and spread rapidly over a large area. This happens in limited fashion in the use of solid carbon dioxide, as discovered by Langmuir. But this is confined, as weather people know, to a particular type of cloud formation and very special conditions of temperature. When these conditions are found, there is not apt to be much moisture present for practical purposes.

The method which has been widely tried over the past few years, the use of silver iodide or similar agents, does not produce a chain reaction but only attempts to provide microscopic particles available for moisture to condense upon and produce ice nuclei. Whether it is successful or not obviously will depend upon whether the condensation at that particular spot requires additional nuclei or not and whether the conditions are such that the condensed moisture will form particles large enough to fall as snow or rain. There is some indication that too much silver iodide inhibits precipitation. We do not yet know the optimum number of nuclei nature needs for precipitation purposes and, therefore, if we provide nature with additional nuclei, do not know whether this will aid or hinder rain formation.

By the above testimony I do not wish to seem unduly pessimistic. Research and experiment to date have shown promise that ultimately we may find a means of weather modification which, hopefully, may be of great practical importance; but evidence to date seems to indicate clearly that generally no large effects will be produced by present means until further basic research has led to great improvement in our understanding of this precipitation process and of the meteorological conditions which may promise more effective results.

For these reasons, I would strongly advocate that at this time a systematic research program be stressed. The problem is one of great difficulty and complexity and should be placed in the hands of only the most competent scientists

and organized teams of scientists. It would seem unwise to attempt to embark upon any program having as its aim the development of means for weather modification until we have some scientific assurance that such means are practical and feasible. It would be even more unwise, in my opinion, to attempt field operations, except as research in appropriate situations, using present techniques in the hope of achieving results of practical importance. Such activities would be misleading, would undoubtedly lead to disappointments and would in all probability involve a waste of money and effort. When one considers that we do not really know whether cloud seeding according to present methods will produce or inhibit rain from many cloud formations, it seems clearly in the public interest not to encourage random or indiscriminate attempts.

I would, therefore, recommend that the legislation or the committee report make it clear that the Congress expects applied research and development work to be undertaken only where the effort holds some promise of success in the light of the knowledge of the underlying phenomena existing at the time.

The provisions of S. 86, while calling upon the Foundation to support an evaluation program, do not provide any authority to secure the necessary information. I, therefore, recommend that S. 86 be amended by adding a section giving the National Science Foundation authority to require by subpena information necessary to carry out the provisions of the act. An example of the provisions which would seem appropriate for this purpose is contained in section 9 (d) of Public Law 256, 83d Congress, 1st session, which established the Advisory Committee on Weather Control.

If S. 86 is enacted, the National Science Foundation intends to press, as a matter of priority, for further effective basic research in the general area of weather modification, particularly in the fields of cloud physics and meteorology. It will carry forward evaluation programs begun by the Advisory Committee on Weather Control, and to the extent that sufficient scientific knowledge is available, initiate and support such applied research or development work as may appear reasonably promising. In undertaking the applied research and development activities, the Foundation would welcome and expect the cooperation of other Government agencies, such as the Departments of Defense, Interior and Agriculture, and the Weather Bureau. It is my understanding that under S. 86 the Foundation could transfer funds to such agencies for these purposes.

With these suggestions I strongly urge enactment of S. 86.

The Bureau of the Budget has advised me it has no objection to the submission of this report.

Mr. KLOPSTEG. May I now say, Mr. Chairman, that I have been Dr. Waterman's alternate, his designee, on the Advisory Committee, and have sat in most of the sessions of that Committee. I have also been and still am a member of the Committee on Meteorology of the National Research Council and both Committees—the Advisory Committee on Weather Control and the Committee on Meteorology—agree on the importance of further research to increase our understanding of the underlying phenomena.

Mr. RHODES. Thank you, Dr. Klopsteg.

Are there any questions?

Mr. NEAL. Dr. Klopsteg, in the past there have been quite extensive studies, particularly by the armed services, in these fields, have there not?

Mr. KLOPSTEG. Yes, sir.

Mr. NEAL. I would presume that were authority given your organization, one of the first things would be to assemble, if that has not already been done, all of the facts that have been brought out that have significance. Your objective in having this bill passed, then, would be to look into the most promising fields of endeavor and to assign further studies in these fields of activity to individuals or groups of individual scientists who you think are capable of going further into the studies. In other words, you would correlate everything that has already been learned and act from there on to discover what potentials there are in the future?

Mr. KLOPSTEG. Mr. Chairman, perhaps I might answer the question by telling you the manner in which the National Science Foundation operates under its act and to indicate the probable procedures for carrying forward its responsibility in this field.

We recognize the fact that in the past the amount of work that has been done in weather control, in weather studies really, or meteorology, in the whole field of atmospheric research has been inadequate as a basis for advancing with great assurance in doing certain things and to accomplish certain modifications. This means that more basic research is required and the Foundation under its act is authorized and directed to encourage and support basic research and education in the sciences. The manner of supporting basic research in the sciences is to seek the advice, through advisory committees, of the most competent people that we can find in a particular branch of science. I think this would be the logical and effective procedure in the field of atmospheric research; namely, to find the most competent people in private life and Government to constitute an Advisory Committee which would guide the undertakings that would then have to be set in operation.

We have a Division of Mathematical, Physical, and Engineering Sciences and we have a Division of Biological and Medical Sciences and we would proceed through the former—as we are already doing—to carry out recommendations of the Advisory Committee and the Committee on Meteorology. We are establishing another section in the Division of Mathematical, Physical, and Engineering Sciences, a section on Atmospheric Research, which would have cognizance of the responsibilities that would be assigned to the Foundation under this act, if passed.

One other point should be mentioned. In our National Science Foundation legislation, as I said before, we are authorized and directed to encourage and support basic research. What S. 86 would add, and an essential addition, is that it would authorize us to support research which is not restricted to basic and fundamental types.

Research would have to be carried on, as our knowledge increases through basic research, in finding ways of applying the knowledge derived from basic research. Obviously, it would make no sense to wait until we knew everything before we started applying it.

In parallel with our efforts in basic research, it should be possible and it is possible under S. 86 to proceed with such applications of knowledge gained through basic research as appear promising in particular areas.

Mr. RHODES. Mr. Dingell?

Mr. DINGELL. Doctor, you referred here to provisions of section 9 (d) of Public Law 256, 83d Congress, 1st session, which established the Advisory Committee on Weather Control.

Would it be possible to lift section 9 and put it into this bill?

Mr. KLOPSTEG. I am not sure and since I have no legal training I would like to ask Mr. Hoff, our General Counsel, to answer that question.

Mr. HOFF. With very few changes.

Mr. DINGELL. Would you submit to this committee a draft of the amendment that you have discussed?

Mr. HOFF. We would be glad to; yes.

(The material referred to follows:)

SEC. —. (a) The Director of the National Science Foundation, or his designee, may, for the purpose of carrying out the provisions of this Act, hold such hearings and sit and act at such times and places and take such testimony as the Foundation shall deem advisable. Any members of the Foundation may administer oaths or affirmations to witnesses appearing before the Foundation or before such member.

(b) (1) The National Science Foundation through the Director, shall be entitled by regulation, subpena, or otherwise, to obtain such information from, require such reports and the keeping of such records by, and make such inspection of the books, records, and other writings, premises or property of, any person as may be necessary or appropriate to carry out the provisions of this Act, but this authority shall not be exercised if adequate and authoritative data are available from any other Federal agency. In case of contumacy by, or refusal to obey a subpena served upon, any person referred to in this subsection, the district court of the United States for any district in which such person is found or resides or transacts business, upon application by the Foundation, shall have jurisidiction to issue an order requiring such person to appear and give testimony or to appear and produce documents, or both; and any failure to obey such order of the court may be punished by such court as a contempt thereof.

(2) The production of a person's books, records, or other documentary evidence shall not be required at any place other than the place where such person usually keeps them, if, prior to the return date specified in the regulations, subpena, or other document issued with respect thereto, such person furnishes the Foundation with a true copy of such books, records, or other documentary evidence (certified by such person under oath to be a true and correct copy) or enters into a stipulation with the Foundation as to the information contained in such books, records, or other documentary evidence. Witnesses shall be paid the same fees and mileage that are paid witnesses in the courts of the United States.

(3) Any person who willfully performs any act prohibited or willfully fails to perform any act required by the above provisions of this subsection, or any rule, regulation, or order thereunder, shall upon conviction be fined not more than $500 for each offense.

(4) Information obtained under this Act which the Foundation deems confidential for purposes of national security or other reasons or with reference to which a request for confidential treatment is made by the person or agency furnishing such information, shall not be published or disclosed unless the Foundation determines that the withholding thereof is contrary to the purposes of this Act, and any member or employee of the Foundation willfully violating this provision shall, upon conviction, be fined not more than $5,000.

Mr. DINGELL. No further questions.

Mr. RHODES. Thank you. I have a number of questions that I would like to have the answers to for the record. If those answers are not available now and if there is no objection on the part of the committee, I would like to have them later.

Mr. KLOPSTEG. Yes, sir.

Mr. RHODES. The last sentence of section 2 provides that in addition to the authority contained in the bill, the Foundation for the purposes of this proposed legislation "may utilize any of the powers granted by the National Science Foundation Act of 1950."

The Foundation, under that act, has a great variety of powers, many of them specifically related to particular things and calculated to achieve particular objectives.

Therefore, is not this particular sentence too vague and indefinite? For example, could the Foundation institute scholarship and fellowship programs for research on weather problems? Is it intended that they shall be able to do so?

Would it not be better to specify the particular powers it is intended that the Foundation shall have?

Mr. KLOPSTEG. I would like to have Mr. Hoff answer that question, Mr. Chairman.

Mr. HOFF. I think in that particular example given we certainly could give fellowships or scholarships under section 10 for basic science in the weather field now. I do not think this would add or detract from what we have. We could enumerate all of the particular clauses, but if you do that, you generally leave out something that is the one thing you want later on.

I would say that no harm would be done by having the general provision and some harm might be done by trying to itemize the particular clauses. I was thinking, in fact, of one thing that should be emphasized and that is that some of the authority in the general act which only relates to basic research should be made specifically applicable to applied research carried on under this act.

Mr. KLOPSTEG. May I add one item?

The Committee on Meteorology of the National Academy of Sciences Research Council recognizes, as I am sure all meteorologists do, the shortage of meteorologists in the United States and therefore this committee has very strongly recommended that steps be taken to increase the number of qualified meteorologists which also can be done under the general authority of the National Science Foundation Act through its fellowship grants.

Mr. RHODES. Mr. Neal?

Mr. NEAL. In other words, your present act gives you that authority?

Mr. KLOPSTEG. That is right, sir.

Mr. RHODES. If all the powers under present law are intended to be available at the discretion of the Foundation, would it not be better to make this proposed legislation a part of the National Science Foundation Act?

Mr. HOFF. I think that could be done just as well and, as a matter of fact, there is a bill introduced in the Senate which has various amendments to our act in it. It could fit in very well with that.

Mr. RHODES. After this bill passed the Senate, the Supplemental Appropriation Act, 1958, became law and it contained a provision requiring the Advisory Committee on Weather Control to terminate its activities by December 31, 1957, and it has actually ceased to operate.

However, section 3 of the bill provides for transferring to the Foundation the functions, duties, and records of the Advisory Committee on Weather Control and provides that the committee is abolished effective December 31, 1957.

Obviously some changes will have to be made in section 3 of the bill, is that correct?

Mr. HOFF. Mr. Rhodes, I have never felt that section 3 did anything as far as we are concerned except to, in effect, make sure that our title to the records was beyond reproach plus, of course, the authorization for appropriations if it is a separate act.

Mr. RHODES. Assuming it is now possible to transfer functions and duties from the Advisory Committee, what functions and duties is it intended to transfer?

The primary functions granted to the Advisory Committee by the 1953 act were those granted by sections 3 and 10 (a); namely, the duty to make studies and evaluations of weather control experiments and to submit reports to the President for submission to the Congress. The

bill already has provisions of a generally comparable nature. Perhaps what section 3 of the bill has reference to are the powers, rather than the functions or duties, which were granted to the Advisory Committee by section 9 of the 1953 act.

If this is so, would it not be much clearer to spell out the powers it is intended that the Foundation shall have? Is this not particularly true in view of the fact that the last provision of section 9 prescribes criminal penalties?

Mr. HOFF. Yes, Mr. Rhodes. Dr. Klopsteg testified that we would recommend including a parallel to section 9 in the bill.

Mr. RHODES. Thank you, gentlemen.

Mr. DINGELL. I have been doing some thinking here about two things. First, what is the amount and the extent of the program that you propose to carry out under this specific piece of legislation, dollar-and-cents-wise? Here we are dealing with a blank check. I would like to know what you folks propose to do with this after we pass this legislation.

Mr. KLOPSTEG. It is a little bit early to prognosticate figures with any degree of confidence, but let me say that as we move into this field more vigorously—we have already been supporting some projects in meteorology as part of our earth-sciences program—we would expect that during the first year of operation for which funds might be asked, we could perhaps usefully apply somewhere near a million dollars. This amount, depending upon the wisdom with which the program is managed and in terms of the advice given us, might grow somewhat during the succeeding years.

The first version of S. 86, as I recall it, provided for $5 million to be authorized for a 5-year program. I think that we can use that as a point of departure to guide our thinking as to the amount involved.

Mr. DINGELL. Would that be an adequate program?

Mr. KLOPSTEG. This will depend, sir, on the number of capable research workers available to carry on the work. Let me add also that probably other funds are going to come into the program if the recommendations of the Committee on Meteorology are carried out. The Committee on Meteorology recognized that of the universities that now have research and graduate work in meteorology, none of them has large and adequate facilities of a type that is needed in field experiments. In order to carry on the research in this vast and complex area of atmospheric research, the Committee recommended the establishment of a National Institute of Atmospheric Research which would be provided with the necessary facilities, such as aircraft that might be required to carry on research, such as radar, such as a device that you might refer to as a rain tower, an enclosure in which laboratory study of precipitation could be carried on, and similar things.

This, in itself, would require a substantial amount of money both for construction and operation and to the extent that basic research were carried on at such an institute, it would, of course, dovetail with, and perhaps also supplement the kind of research envisioned in S. 86.

Mr. DINGELL. May I ask this question: The National Science Foundation assumes all responsibility for translating and watching Russian technical works?

Mr. KLOPSTEG. We have a program of support for translating certain Russian journals.

Mr. DINGELL. Have you any indication of what they are doing in this field today?

Mr. KLOPSTEG. We have nothing directly that has come to us. I believe that possibly the question might well be asked of CIA.

Mr. DINGELL. I understand that they are spending half a billion dollars, but you folks are also spending something.

Mr. KLOPSTEG. We have heard that the Russians have done a great deal of meteorologic research in the Arctic, especially, and they have made many, many landings; between 4 and 5 thousand aircraft landings on some of the large ice islands, for meteorologic studies.

Mr. DINGELL. This is a good bill as far as it goes, but just to take an instance, do you recall Senator Case, who was very active in getting this bill passed in the Senate, mentioned that he had some pilot seeding and the rain same down 5 miles from where he wanted that to come down. I assume that his neighbors wanted that water.

Mr. KLOPSTEG. We hope they did.

Mr. DINGELL. But it is not unlikely that a man could cause precipitation and might create a flood in one area where he did not want it. There are any number of harmful effects. He might be stealing his neighbors' water in effect.

Mr. KLOPSTEG. That is quite correct, and I think Captain Orville could give you an instance mentioned in the early days of the Advisory Committee where there were some wheat growers and cherry growers in adjacent territories. One wanted water and the other did not. To control it there, you would have to be able to control the fall of percipitation at a very narrow zone.

This points up what I think you may have noticed in Dr. Waterman's statement, that before we can control, we must know pretty well in advance what would happen if we did not try to control and then interpose whatever seems proper to bring about the result we desire.

Mr. DINGELL. I was leading up to a very definite point.

This country has been plagued with rainmakers since early days, responsible and irresponsible.

What assurances will we have, or what steps are you going to take, or what legislative measures should we take, to assure knowledge gained by this is not applied recklessly, carelessly, or by ignorant individuals to the great detriment of their fellowmen?

Mr. KLOPSTEG. I am sorry that I did not get the full implication of your question.

Mr. DINGELL. You recall that this country has been plagued with rainmakers since very early days.

What assurance can you give us, or what legislative action should we take, or what administrative action can you take, or would you recommend, to keep the knowledge that is going to be derived from the program, from falling into the hands of ruthless, ignorant, or careless, or reckless individuals?

Mr. KLOPSTEG. The first answer that comes to my mind is that the more knowledge we get, the better it will be all around. So far as motives of people are concerned, I do not know how one can legislate to control them, whether they use the information honestly, or whether they use such information carelessly and principally to their own advantage.

I have no answer except to say that we certainly must watch as we go along to see what happens and to the best of our ability see that only the reasonable and proper things are done.

Mr. DINGELL. You do not have any specific recommendations?

Mr. KLOPSTEG. I have no specific recommendations.

Mr. HOFF. I might add a word or two on that.

In many of the States where there is legislation today, it is of the type of giving notice, prior notice, of weather modification efforts. As far as the Federal Government is concerned, personally, I think it is a little early to recommend any particular legislation. I think that is part of the job of evaluation as more knowledge is gained; it would be part of our responsibility, at the appropriate time, to come back with suggestions as to possible legislation in this field.

Mr. DINGELL. You do feel that there is room for this committee and your branch of the Government to look into the field as the project goes along?

Mr. HOFF. Yes, and as more knowledge is gained.

Mr. KLOPSTEG. The Advisory Committee had that obligation also, to look into the legal situation and its report contains a section on the legal situation which, in part, may answer your question.

Mr. DINGELL. Thank you.

Mr. RHODES. Before you leave, Mr. Klopsteg, could you tell the committee where the records of the Advisory Committee are at the present time?

Mr. KLOPSTEG. It is my understanding, although I have not seen them personally, but I have been told, that we have them now in custody at the National Science Foundation.

Mr. RHODES. Thank you, sir.

Mr. KLOPSTEG. Thank you, sir.

Mr. RHODES. Our next witness will be Dr. Francis W. Reichelderfer of the Weather Bureau, Department of Commerce.

STATEMENT OF DR. FRANCIS W. REICHELDERFER, CHIEF OF THE WEATHER BUREAU, DEPARTMENT OF COMMERCE, WASHINGTON, D. C.

Mr. REICHELDERFER. I do not want to repeat, Mr. Chairman, what has already been said so I will speak from my notes to cover some of the points that may be of interest to you, expressions of views of the Weather Bureau.

Much has been said and written about cloud seeding as a means for augmenting rainfall. After 10 years of experimentation, compromising thousands of individual cloud seeding tests, costing in total many millions of dollars, there is still much uncertainty as to the real possibilities.

As is the case in most problems in science and engineering, the answers will be found only by extensive research. On this point, practically all agencies and individuals that have been active in this field are essentially agreed.

Well-planned and comprehensive basic research in meteoroogy is urgently needed to gain the knowledge necessary, not only for determining what can be done about weather modification, but also for developing the means for better predictions of severe storms, their genesis, movement, and extent.

This urgent need for basic research in meteorology has been emphasized recently by several independent groups, the American Meteorological Society, the Committee on Meteorology of the National Academy of Sciences, the President's Advisory Committee on Weather Control, and others.

References to some of these recommendations are given at the end of this statement.

The Department of Commerce and the Weather Bureau were given opportunity to express their views on the importance of research in relation to weather modification in the hearings of the Senate Subcommittee on Interstate and Foreign Commerce last year. Statements are contained on pages 114 through 131 of the printed record of hearings on S. 86, March 28 and May 13, 1957.

Without repeating the testimony in detail, the following brief remarks sumarize the principal points.

I need not recount the influence of weather and climate on the everyday business activities and personal interests of people everywhere Extremes of weather with their disastrous consequences are always with us, such as droughts or floods, cold waves or prostrating heat, hurricanes and tornados, etc. Man's knowledge of meteorology should be as basic and comprehensive as his knowledge of the sciences of physics and chemistry, for example; yet we know relatively little about the particular processes of condensation of moisture in the free air and its coalescence into snow and rain. There are great gaps in our data of conditions in the atmosphere and many of the basic factors and mechanisms of weather and climate are still unknown or unsolved.

The International Geophysical Year is providing many meteorological observations never before available, but it is only a beginning. The new data will require extensive research. It seems quite obvious that there is pressing need for basic research along the lines visualized in S. 86. We believe this research must be fundamental in nature. Meteorological studies involve some of the most complicated physical and perhaps chemical processes to be found anywhere and they require coordinated research by the most competent scientific staffs experienced in this field. This research does not lend itself to distribution among a large number of research laboratories with little or no experience in meteorological science. Experiences of the last decade have shown quite plainly how easily the inexperienced may be misled in experimenting in cloud seeding. Coordination of the research program under the National Science Foundation as now proposed in S. 86 would provide for well-planned and closely related projects or programs by research organizations well qualified to advance man's knowledge of meteorology and its applications.

One of the first problems to be solved in cloud seeding is how to distinguish between rain that comes entirely from natural causes and rain that is induced artificially. Because of this difficulty, the thousands of tests of cloud seeding in the past have been attended with many uncertainties as to the results. At present the methods of seeding in hope of increasing rainfall are very similar to those used for suppressing cloud development and preventing formation of hail and lightning, and usually the experimental design has not provided definite means for distinguishing between the two processes.

Some experimenters have even held that seeding decreased rainfall. Certainly we have been operating in a field characterized primarily by ignorance of what actually is going on in the clouds.

Strong reasons for basic research in meteorology are also found in the twofold benefits that should be gained. The program should open the way to whatever practical possibilities there may be in cloud seeding and other forms of weather modification and at the same time yield the knowledge on which to build better methods of weather forecasting and incipient storm detection and prediction. Most of the comprehensive basic research programs in meteorology will serve both purposes.

Weather forecasting and storm-warning services have advanced very considerably during the last few years since radar and other improvements in meteorological techniques have become available. Present inadequacies and occasional errors in predictions come primarily from lack of meteorological data and incomplete knowledge of the mechanisms of weather and storms.

In addition to radar, there are other rather recent technological developments that give the basis for greatly increased research in meteorology with good reason to expect successes now where such a comprehensive program a few years ago would have been either impossible or unlikely to succeed. Among these developments are the high speed electronic computer and the earth satellite.

Already the computer is leading the way to improvements in the techniques of weather forecasting. It has also proven itself a powerful means for research in the consequencies of weather control. You are doubtless informed through articles in the press that if the polar icecaps were melted, the resulting rise in sea level would inundate many of the largest cities in the world. Other forms of weather modification would doubtless have consequences that must be understood in advance. For example, one proposal for increasing rainfall in semiarid regions is based on plans for causing more water to be evaporated from the oceans, thus providing more moisture in the air to augment normal precipitation. But we should not forget that humid air is one of the contributing factors to formation of hurricanes and tornadoes. Therefore, it is important to understand the whole process and determine what artificial methods would give beneficial results in weather modification without disastrous consequences. The general circulation studies of the Weather Bureau at Suitland, Md., are leading toward knowledge of this general nature.

Much of the research in which the Bureau is now engaged, including the national hurricane research project in Florida, and the tornado research studies in Kansas City, are closely related to the general program provided under S. 86 and the several projects would be well coordinated so as to supplement one another without duplication.

The Bureau expects to continue the basic and applied research that relates directly to its responsibilities for forecasting the weather and warning of severe storms.

During the last few years, many conferences and evaluation studies have been made of cloud-seeding tests.

They have been reviewed by leading scientists in the field of cloud physics and symposiums have been held in scientific meetings to bring out the conclusions. A 4-day symposium was held at Woods Hole Oceanographic Institute in September 1955 and another at the In-

stitute for Atmosphere Physics, University of Arizona, in April 1956. These and other studies show that meteorologists everywhere are very active in the search for the possibilities of weather modification and its practical applications, but they are seriously handicapped by lack of knowledge in some very vital segments of the science. Much of the experimentation in cloud seeding during the past 10 years has been inconclusive because of the lack of basic knowledge, and many of the unsubstantiated claims which have led people to think these problems already solved, stem from this lack of knowledge. The solution is most likely to be found through the research proposed in this legislation and we endorse it strongly.

It is my understanding, Mr. Chairman, that the amendment to the original bill, S. 86, now incorporated in this bill, providing for coordination under the National Science Foundation, was adopted in order to place this entire, complex program under a disinterested but nevertheless very competent research organization. We believe that this is a very essential part of the plan if it is to be successful.

It is also my understanding that the amendment now included in the present draft of the bill, S. 86, has rather general agreement, not only among the Government agencies concerned, but also among the private agencies and individual representatives who are engaged in cloud seeding.

This concludes what I have to say except for the references to which I alluded at the beginning of my statement, may I present them to the recorder to be included in the record? There are four of them.

Mr. RHODES. Without objection, they will be included.

Mr. REICHELDERFER. Thank you, sir.

(The references referred to are as follows:)

REFERENCES

1. Interim Report to the Council of the American Meteorological Society by the Committee for the Encouragement of Meteorological Research, May 1957.

2. Research and Education in Meteorology—National Academy of Sciences, January 1958.

3. Final Report of the Advisory Committee on Weather Control, Volume I, December 1957.

4. List of Weather Bureau Research Papers, pages 126–129, Senate hearings on S. 86, 1957.

Mr. RHODES. Thank you, Doctor.

Any questions?

We may be having a quorum call any moment. I note that we have a number of distinguished witnesses still to be heard. To avoid coming back, those who wish may make a few brief remarks and file your complete statement in the record.

Mr. NEAL. Doctor, this bill would specifically allocate or set aside, or earmark funds for this particular objective.

May I ask how many of the activities of the National Science Foundation are now being appropriated specifically for certain parts of your work, certain phases of your work?

Mr. REICHELDERFER. Dr. Klopsteg of the Foundation could probably answer that better than I. I can say this, however: There is little, if any, in the regular appropriations to the National Science Foundation that bears directly on the responsibilities of the Weather Bureau as regards forecasting and warning storms. There are 1

or 2 projects in meteorological research in which we have been interested, the Weather Bureau, because of their relation to our responsibility but which we were unable to finance, and the National Science Foundation has provided funds for these studies to be carried on at the universities concerned.

Mr. NEAL. Do I understand you correctly, when I asked you if practically all of the activities engaged in by your organization are carried on by funds appropriated specifically for some particular phase of your activity, or do you get your appropriation in one lump sum?

Mr. REICHELDERFER. The Weather Bureau gets its primarily in one lump sum for salaries and expenses, under that general heading.

Mr. NEAL. If you were not to have this particular measure passed, you would go before the Appropriations Committee next year and ask for an increase in funds for this particular phase of the work? Would that be the same advantage to you that you have had in the past?

Mr. REICELDERFER. We have asked in the past almost each year for additional funds for research along this line to be appropriated, not for the total research program—not for the program that visualizes as comprehensive research as is contained in S. 86, but rather for projects that deal directly with weather forecasting, weather reporting, and storm warnings. Perhaps I have not answered that clearly.

Mr. NEAL. The reason I asked that is, do we by periodic legislation appropriate funds for projects as they come up and thereby perhaps complicate the whole system of appropriations? I wondered if it could be possible for the National Science Foundation to apply to the Appropriations Committee annually, particularly specifying the various activities they want and justify appropriations for that amount and make it a good bit simpler than the present method of legislating from time to time, piecemeal, the type of thing that we do.

Mr. REICHELDERFER. Certainly it is my understanding that one of the purposes of the bill is to bring all of this related weather modification research together.

Mr. NEAL. In this particular line of the National Science Foundation's activities?

Mr. REICHELDERFER. That is my understanding, yes.

Mr. NEAL. I think there is no doubt but what this appropriation is justified. I do not think there is any question but what the bill is justified.

The reason I ask you that question is to try to make it more comprehensive to the people who sit on the Appropriations Committee to know that your science foundations are doing certain types of work, that you apply to them, and you specify and delineate the type of things you are going to do and the amount of money needed, and ask for an appropriation in a single sum to carry that on.

Would it not be simpler legislation for it to be done that way?

Mr. REICHELDERFER. It seems to me that a coordinated plan is certainly better for a program of this kind, a comprehensive program.

On the other hand, the Weather Bureau has funds for hurricane research as such. I think this is so closely related to our responsibilities for storm warings that there——

Mr. NEAL. Pardon me, but that Bureau is not administered through your organization?

Mr. REICHELDERFER. I represent the Weather Bureau. I do not represent the National Science Foundation.

Mr. NEAL. You do not represent the National Science Foundation?

Mr. REICHELDERFER. I do not.

Mr. NEAL. Yours is a separate institution, separate item?

Mr. REICHELDERFER. That is correct.

Mr. NEAL. Thank you, sir.

Mr. RHODES. Thank you, Dr. Reichelderfer.

We will meet again tomorrow morning at 10 o'clock. Those of you who have come any distance and want to get away, can file your statements for inclusion in the record.

We have Dean A. M. Eberle, formerly vice chairman of the advisory committee on weather control of South Dakota State College.

Would you care to come back in the morning?

Mr. EBERLE. Yes, Mr. Chairman. I will come back in the morning.

Mr. RHODES. Who cannot come back tomorrow? Who would like to make a brief statement now before we adjourn?

Mr. LANGFITT. I do not have any oral statement to make except that we have had a controlled project in our area and I would like to comment on that, if anyone would desire any information about it.

I have a written statement that I would like to file.

Mr. RHODES. Without objection, it will be filed.

(The statement referred to follows:)

STATEMENT OF MERRILL J. LANGFITT, FARM SERVICE DIRECTOR, KMA, SHENANDOAH, IOWA

Mr. Chairman and members of the committee, it is a pleasure to appear before this committee for the purpose of expressing my views relative to legislation for studies of and research in weather modification and in addition, all applications of weather.

I would like to first preface my remarks by saying that I am farm service director for radio station KMA at Shenandoah, Iowa. We are a regional, 5,000-watt station, serving the heart of the Corn Belt and have been in operation as the farmers' radio station for 33 years. In view of the importance of weather to farmers and the critical importance of weather to farm income, we are vitally interested in weather and all its ramifications. I spearheaded the organization of an 8-county weather modification program which has been in operation for 2 successive years. Prior to 1956 I did some experimental cloud seeding with dry ice in the southwest Iowa area.

In view of the fact that so little seems to be known about weather modification, at least as an exact science, it seems appropriate that we must not waste more time in carrying out research in this field with the thought in mind of finding answers. We in the Corn Belt are much more interested in knowledge and facts on the subject than we are in theories that weather modification is or is not practical. The President's Advisory Committee has reported that weather modification is now a proven science, but that where and when it is most effective is not conclusively answered to this date. In consideration of the work that has already been done, it seems logical to proceed from here and go forward with some progressive research to prove the unknown factors.

I frankly have not been completely satisfied with the progress the United States Weather Bureau has made in this field. I don't feel they have reached out as far as they could or should in the field of weather research. Much too little has been done in weather research as it relates to agriculture. If Russia continues to advance in science as she has already shown she is capable of doing, we in this hemisphere cannot afford to continue to be slowed down by jealousies, technicalities, and continual bickering among the private and public agencies capable of advancing the science of weather modification. I commend the Weather Bureau for the forecasting services they now render, but at the same time I want to be on record to the effect that present forecasting procedures are not adequate. Longer-range forecasts must be developed and surely this

can only come through more knowledge of weather phenomenon. I want to say that I am not trying to pose as an authority on the subject, but for the record, I do have a bachelor of science degree from Iowa State College. The fact is, we have very few authorities in this country in the field I am discussing. I'm sure we need more of them—and fast.

Weather is important militarily, but likewise it is important in the field of food production. It is the latter field in which I am primarily interested. When we have moisture we produce food. Conversely, when we have drouth, we do not produce food.

My proposals are these:

1. We must not lose any of the research that has already been done by the Weather Bureau, private operators, power companies, farmers, or anyone else who has studied the subject.

2. We must make sure that no individual or no group, Government bureau or otherwise, shall have complete control of future research.

3. We must have a factfinding body, properly decentralized and properly constituted, removed from prejudices and complacencies, with the brainpower and initiative to move forward, responsibile only to Congress.

4. We must have adequate funds for such a committee to progress the science so that America can be the leader in a worldwide competition to control weather.

5. We must have funds above and beyond committee requirements so that properly organized lay groups can lend some assistance to research.

6. We must have funds so that professional groups can be assisted to the point of contributing to the total effort (college and univerity people, etc.).

7. We must inform the public of progress being made in an effort to eliminate any prejudices or fears individuals may have.

8. We must continue to apply our knowledge on practical projects in an effort to prove or disprove research conclusions and improve techniques.

9. We must keep our private-enterprise system foremost in mind and give those groups an opportunity to contribute their knowledge to the field of weather research.

10. It appears that speed of action to facilitate new and additional weather research is of the greatest importance.

Now I am convinced, after 2 years' experience in a controlled area, that some weather modification can be achieved. I am, by no means, convinced that we can turn precipitation on or off as we may desire. At the same time, I feel confident that such is within the realm of possibility. On the subject of research, if the day were here when farmers could have an accurate long-range forecast for a year in advance, much of the gamble could be eliminated from farming. I feel that we are on the brink of such achievement, but the break-through has not been accomplished to this date. Without any governmental assistance we might achieve an accurate 12-month, long-range forecast in 5 to 10 years. With some immediate help, it seems inevitable that we could be there in 2 years or less.

It seems to me that people in authority are going to have to make up their minds whether we are going to stand still in the field of weather modification and control, or whether we are going to go some place fast. Our very way of life is greatly dependent on the weather. He who first achieves weather control may easily write the history of man's future years on earth. The stakes are too high for us to fail in this endeavor. The development of all of the last sciences of food production could very well be dwarfed by the development of perfecting the science of weather in all of its phases.

Mr. DINGELL. Would you please give us your full name and tell us whom you represent?

Mr. LANGFITT. My name is Merrill J. Langfitt and I am the farm service director of radio station KMA, Shenandoah, Iowa.

Mr. RHODES. Is there anyone else?

Mr. ORVILLE. My name is Capt. Howard T. Orville, former Chairman of the Advisory Committee on Weather Control. I will be able to come back tomorrow morning.

Mr. RHODES. Is there anyone else who cannot come back tomorrow and wishes to file a statement now?

If not, the meeting will be adjourned.

(Thereupon, the hearing was adjourned at 12:05 p. m.)

WEATHER MODIFICATION RESEARCH

WEDNESDAY, MARCH 19, 1958

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON HEALTH AND SCIENCE,
OF THE COMMITTEE ON INTERSTATE AND FOREIGN COMMERCE,
Washington, D. C.

The subcommittee met, pursuant to recess, at 10 a. m., in room 1334, New House Office Building, Hon. George M. Rhodes (acting chairman of the subcommittee) presiding.

Mr. RHODES. The committee will please come to order.

STATEMENT OF HON. GEORGE S. McGOVERN, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF SOUTH DAKOTA

Mr. RHODES. The subcommittee is meeting this morning to resume the hearings on S. 86 and related bills, to establish a program for research in weather modification.

We are privileged to have as our first witness one of our distinguished colleagues, the Honorable George S. McGovern, of South Dakota.

Mr. MCGOVERN. Mr. Chairman and members of the committee, I appreciate this opportunity to make a brief, informal statement today in support of this bill with some modifications in the bill as it is now written.

I might say that I am not a sponsor of the legislation under consideration, but two of my South Dakota colleagues are, Congressman Berry from the Second District of South Dakota and Senator Case, and I certainly want to join in their efforts in support of this legislation along with the other sponsors of the bill.

Now I know that there are several people in the hearing room here today who are nationally known and internationally known experts in this field, some of whom come from my own State, Mr. Di Santo and Dean Eberle of South Dakota State College. I certainly don't want to infringe on their time. I could not help but think, as I looked out the window here a few minutes ago, that these people are very efficient; they have already brought on rain after arriving here in Washington only a couple of days ago. I think that speaks very well for their effectiveness. We may not need rain here in Washington, but there are a great many parts of the country where we do.

I think this is a field of legislation that is very vital to the Congress and to the whole country.

Just the other day I was reading an authentic report which came from the Soviet Union, pointing up the efforts that they are undertaking in this field.

I do not like to think that we have to wait for a challenge from behind the Iron Curtain before we begin to move on an important legislative matter, but sometimes it does help to keep our eye on what our competition is doing. Certainly they are making very definite strides in this field, recognizing the close relationship between food production and their strength in the cold war struggle in which we will probably be engaged for many years to come.

There is no asset that we have here in the United States that is any more fundamental, in terms of our own strength, in our struggle to preserve our way of life than our food production.

I think sometimes we underestimate the tremendous factor that food production is in our total national strength. You may remember during both World War I and World War II that we developed a slogan, "Food Will Win the War." I think in a very real sense that was more than a slogan; that our ability to feed our own armies and our own civilian population and to take care of some of the food needs of our allies was a very important factor in our success in both of those two great contests.

But even in times of peace, food is of tremendous importance to our national strength and in terms of our ability to meet our commitments all over the world. Toward that end, as a representative from a farm State, I am very much interested in any research proposal, or any kind of a proposal, that might strengthen our ability to produce food or to produce it on a more secure basis, so that we can eliminate some of the hazards that are involved in this very important matter of producing food for our own tables and for the tables of the world.

I want to urge the committee and the Congress to give very serious consideration and to take action as soon as possible on this proposal to accelerate research and development in the field of weather modification.

There are just two suggestions that I would like to make to the committee, and I know that there are people here who are qualified technically to outline the reasons for these suggestions.

First of all, I am convinced that any kind of research in this field ought to include applied research as well as basic research.

It doesn't accomplish very much to confine research to pure theory if we cannot experiment and apply some of that research in a practical manner.

I think the bill ought to make very clear that any funds which the Congress sets aside for research on weather modification ought to be available, not only in the field of basic research but in applied research.

The second suggestion that I would make is very closely related to the first one and that is that support for such research ought to be available to private institutions as well as to Federal and State institutions. Some of the finest work, in fact most of the really excellent work that has been done in this field, has been carried on by private institutions and if funds are to be made available to carry on such research in the future, by the Congress, it ought to be made available to the private foundations and private groups, as well as to State and Federal agencies.

As a matter of fact, one of the Federal agencies that might be involved in this bill has actually ridiculed the whole matter of weather modification. This does not necessarily mean that the program is bad

because it is ridiculed, because it has not been long since people were ridiculing the idea that we could launch a satellite, or, someday launch a rocket that might reach the moon. Ridicule itself has no bearing on the program, but it seems to me it would be ill advised to place the control, particularly of the application of the research in this field, in the hands of an agency that for years has been ridiculing developments in this field.

This would be a perfect example of putting the fox in charge of the chicken coop. Certainly if we are going to see any success in the program it must be handled by people who are sympathetic to it and who have some vision and courage and imagination in exploring all the possibilities in this very important field.

Mr. Chairman, that is about all I have to suggest to the committee and I thank you again for the opportunity to appear here.

Mr. RHODES. Thank you very much for your statement, Mr. McGovern.

Any questions?

Mr. LOSER. I would just like to say this to my distinguished colleague—that he has made a magnificent statement about this bill and I want to very heartily commend him for it.

Mr. MCGOVERN. I appreciate that, Mr. Loser.

Mr. NEAL. I am sorry I didn't get to hear your complete statement. I want to discuss whether research should not be basic and practical, as well, and I wonder if we might go far enough to draw the line between the point where information through basic research becomes available to the public and to industry. Where would you draw the line between the appropriation of Federal funds for basic and practical research?

In other words, shouldn't the Government, after basic research becomes available to industry, cease to become financially responsible for practical research? That is my point.

Mr. MCGOVERN. I do not know whether I fully understand your question, Mr. Neal, but I do not want to give the impression that I am opposed to funds being used for basic research, but as the bill is now drafted, placing the program in the hands of the National Science Foundation, which is authorized to carry on only basic research, it seems to play down the use of such funds for the practical application of research findings, and all I am saying is I think the bill ought to make it perfectly clear that some of this money should be available for applied research.

Mr. NEAL. That is the very point I am trying to bring out. When you extend Federal funds beyond the point of furnishing basic research information to individuals and corporations and groups, then you are getting into a very far-reaching potential insofar as Government operations in industry or anything else is concerned.

My thought is there should be a line of demarcation as to how far these funds might be used in any of these projects, whether it is basic research in weather or what not.

When the Federal Government appropriates money and encourages and allocates funds for basic research and makes that basic research information available to industry and industry people who might be inclined to go along and develop these things, it would seem to me that that is as far as the Government should go.

Mr. McGovern. Well, that, of course, is a matter of personal opinion, Mr. Neal, and I respect your view on it, but it just seems to me that we would be limiting the effectiveness of the money that we allocate to this program if we limited it purely to basic research. I think we will get more for the dollars spent if we do not limit it in that fashion.

Mr. Neal. That is a matter of personal opinion.

Mr. McGovern. Yes.

Mr. Neal. Thank you.

STATEMENT OF HOWARD T. ORVILLE, TECHNICAL CONSULTANT, FRIES INSTRUMENT DIVISION, BENDIX AVIATION CORP., BALTIMORE, MD.

Mr. Rhodes. Our next witness is Howard T. Orville, captain, United State Navy (retired), formerly chairman of the Advisory Committee on Weather Control, and now technical consultant, Fries Instrument Division, Bendix Aviation Corp., Baltimore, Md.

Mr. Orville. Mr. Chairman, I have a short prepared statement here, which is an impartial statement based on some 235,000 miles of travel with the various task forces with the Advisory Committee on about 48 different trips in which there was anywhere from 2 to 4 members of the Advisory Committee that made these field trips into the high Sierras, out into the Dakotas and the drought area at that time and made personal observations of the cloud seeding operations in those States; so that the final report, which was sent to each Member of Congress, and my statement here, which is a very brief one, outlines the results of those findings covering a period of about 4 years.

Mr. Chairman, if I may, I would like to read this statement into the record.

Mr. Rhodes. Proceed.

Mr. Bush. Before you do that, Mr. Orville, you were a member of the Advisory Committee?

Mr. Orville. I am past Chairman of the Advisory Committee on Weather Control. This was a temporary committee.

Mr. Bush. The Advisory Committee was set up to advise the National Finance Committee?

Mr. Orville. No. It was set up, the Advisory Committee on Weather Control was set up to make a study and evaluation of all weather observations, both public and private, and to determine what the United States policy should be. This was a committee established by law in August 1953, and it was an 11-man committee, 5 members from private life who have qualifications in business, agriculture, and science, and 6 members from Government departments including Dr. Waterman, the Director of the National Science Foundation. That made up the Advisory Committee on Weather Control which was disestablished on December 31, 1957, when the Committee submitted its final report to President Eisenhower and went out of business.

Now if I may read my statement, Mr. Chairman?

Mr. Rhodes. Proceed.

Mr. Orville. This is the statement of Howard T. Orville, vice president, Beckman & Whitley, Inc., and past Chairman Advisory

Committee on Weather Control, before the Subcommittee on Health and Science of the House Committee on Interstate and Foreign Commerce.

Mr. Chairman and members of the committee, it is my pleasure to appear before you today to set forth my personal views in favor of S. 86, a bill to provide for research in weather modification. This bill, as I understand it, would direct the National Science Foundation to initiate and support a program of study, research, and evaluation in the field of weather modification, and to report annually to the President and the Congress thereon.

Before its disestablishment on December 31, 1957, the Advisory Committee on Weather Control had unanimously recommended the enactment of this bill into law. The need for such legislation has been cited in several instances in the final report.

Your attention is respectfully invited to the summary of findings, recommendations, and recommendations for general meteorological research, contained on pages vi, vii, and viii of volume I of the final report of the Advisory Committee on Weather Control, and I have a copy of this volume with those references, if you care to have them inserted in the record.

Mr. RHODES. Without objection, it will be done.

(The material referred to follows:)

SUMMARY OF FINDINGS

A. On the basis of its statistical evaluation of wintertime cloud seeding using silver iodide as the seeding agent, the committee concluded that:

(1) The statistical procedures employed indicated that the seeding of winter-type storm clouds in mountainous areas in Western United States produced an average increase in precipitation of 10 to 15 percent from seeded storms with heavy odds that this increase was not the result of natural variations in the amount of rainfall.

(2) In the nonmountainous areas, the same statistical procedures did not detect any increase in precipitation that could be attributed to cloud seeding. This does not mean that effects may not have been produced. The greater variability of rainfall patterns in nonmountainous areas made the techniques less sensitive for picking up small changes which might have occurred there than when applied to the mountainous regions.

(3) No evidence was found in the evaluation of any project which was intended to increase precipitation that cloud seeding had produced a detectable negative effect on precipitation.

(4) Available hail-frequency data were completely inadequate for evaluation purposes and no conclusions as to the effectiveness of hail-suppression projects could be reached.

B. On the basis of its physical evaluations, the committee concluded that:

(1) The conventional seeding with silver iodide generators on the ground is a valid technique for producing ice crystals in favorable summer and winter storm situations. (Formation of ice crystals is thought to be essential for the initiation of precipitation from most cold clouds. However, it is relevant to observe that precipitation does not necessarily follow.)

(*a*) Measurements of silver iodide particle concentrations at points several miles distant from the generators were compared with the estimated concentrations there. On the basis of the limited tests made, it was found that the rate of deactivation was low enough to be of no great concern for practical seeding, even during the "adverse" decay conditions of bright sunlight and warm temperatures.

(*b*) Silver iodide particles in sufficient concentrations to produce seeding effects were found at distances up to 30 miles from the ground generators in particular tests.

(2) Measurements and cloud observations in various regions throughout the United States have indicated that sometimes there is a deficiency of natural

ice-forming particles effective at the temperatures at which ice crystals are formed on silver iodide.

RECOMMENDATIONS

The development of weather modification must rest on a foundation of fundamental knowledge that can be obtained only through scientific research into all the physical and chemical processes in the atmosphere. The Committee recommends the following:

(1) That encouragement be given for the widest possible competent research in meteorology and related fields. Such research should be undertaken by Government agencies, universities, industries, and other organizations.

(2) That the Government sponsor meteorological research more vigorously than at present. Adequate support is particularly needed to maintain continuity and reasonable stability for long-term projects.

(3) That the administration of Government-sponsored research provide freedom and latitude for choosing methods and goals. Emphasis should be put on sponsoring talented men as well as their specific projects.

(4) That an agency be designated to promote and support research in the needed fields, and to coordinate research projects. It should also constitute a central point for the assembly, evaluation, and dissemination of information. This agency should be the National Science Foundation.

(5) That whenever a research project has the endorsement of the National Science Foundation and requires facilities to achieve its purpose, the agency having jurisdiction over such facilities should provide them.

RECOMMENDATIONS FOR GENERAL METEOROLOGICAL RESEARCH

The Committee recommends that a research program include work along the following lines:

(1) The effect of solar disturbances on weather.

(2) The factors which control our global atmospheric circulation.

(3) The factors which govern the genesis and movement of large-scale storms.

(4) The dynamics of cloud motions.

(5) The processes of rain and snow formation, and the relative importance of the physical phenomena which govern these processes.

(6) The electrification process in clouds, and the role electricity plays in meteorological phenomena.

(7) The natural sources of condensation and ice-forming nuclei, and their role.

(8) The methods, materials, and equipment employed in weather modification.

Essential to the foregoing program is the development in large numbers of highly qualified research scientists in this field, a point brought out elsewhere in this report.

The above recommendations, all of which demand basic and fundamental investigation and research, emphasize the meagerness of our present knowledge. These recommendations also reflect the complexity of the problems that must be investigated to provide the basic scientific knowledge that is essential to a technology of weather control.

Therefore, the committee recommends the enactment of S. 86, 85th Congress, which directs the National Science Foundation to initiate, coordinate, and support such a program.

Mr. ORVILLE. It is my opinion that a continued and stable research program in weather modification should be established at the earliest practicable date. It is believed that S. 86 should provide for funds being authorized to the National Science Foundation for periods up to 5 years. These allocations should be available in any desired amount annually, during this period.

Experience has shown repeated failures in achieving desired results because of the uncertainty of annual allocations of funds. I would therefore recommend a provision which would permit the National Science Foundation to request and receive funds through normal budgetary channels for designated research programs which are expected to be active for a period up to 5 years.

It is my personal opinion that a greatly extended research program should be started at the earliest practicable date. This program should be carefully developed and guided by scientists of the highest competence in their respective fields. These scientists should have such qualifications in chemistry, physics, mathematics, atmospheric electricity, climatology, meteorology, and other fields that might assist in the development of a well rounded research program. This program should include projects in 10 to 12 areas in the United States in order to permit a study of all climatic conditions where one or more atmospheric processes may be operating, alone or in combination, to cause the weather phenomena which are experienced in each area.

It is my personal observation that there has been too much complacency in establishing an appropriate research program in weather modification. In its final report, the Advisory Committee on Weather Control has repeatedly emphasized the meagerness of our knowledge of the physical and chemical processes in the atmosphere.

Your attention is respectfully invited to statements contained in the final report, one by Dr. Vannevar Bush, now chairman of the Corporation of the Massachusetts Institute of Technology, and Prof. Henry G. Houghton, chairman of the Department of Meteorology of the Massachusetts Institute of Technology.

Similar statements have been made by Senator Lyndon B. Johnson, chairman of the Military Preparedness Committee, and Dr. Edward Teller of the University of California. Copies of these latter statements are available for the record if you desire them.

All statements emphasize the need and urgency of establishing a greatly accelerated and expanded research program on a carefully controlled basis. It is not believed that any of them would desire a "crash program," nor would I so recommend.

In view of the above comments it is my opinion that the priority assigned research in weather modification should be the same as that for guided missiles and statellite development.

In the light of events since October 1957, it would appear that the Defense Department and the State Department should again carefully review current research programs presently underway in weather modification.

The recommendations given by the Advisory Committee on Weather Control in volume I of its full report reflect the complexity of the problems which must be investigated to provide the best scientific knowledge that is essential to the technology of weather control. For this reason it seems appropriate that a careful review of the military and propaganda implications be carefully reviewed by these departments.

With reference to S. 86 the following comments or suggested changes are submitted for consideration:

(*a*) Page 2, line 19, insert the word "hurricanes" between the words "experienced" and "floods."

The reason for that recommended change is because there has been discussion of eventual attempts to modify hurricanes. Of course that would probably be in the distant future.

(*b*) With reference to page 2, lines 22, 23, and 24, it is my opinion that the National Science Foundation would receive more substantial assistance in the development of this research program if a special

commission comprised of meteorologists and scientists in private life be appointed to carry out the objectives for the development of an appropriate research program.

This suggestion is based in part on experience gained from the evaluation program of the Advisory Committee and in part from observations of other Government-sponsored projects.

(*c*) Page 3, section 3 is a very important provision of this bill. If the National Science Foundation is to carry out its responsibilities, it is most essential that it should have the same authority and the same responsibilities as the Advisory Committee on Weather Control had in Public Law 256. It must have access to information on commercial cloud-seeding operations to insure close coordination, unnecessary duplication, and a free exchange of ideas in order that maximum results may be obtained from Government-sponsored research program. For example, possible contamination of control areas by commercial cloud seeding might give very misleading results.

(*d*) A provision which would permit the National Science Foundation to receive appropriations which would be effective over a period of 5 years. This provision is desirable for stability and continuity of basic and applied research.

Subject to the above suggested changes, I recommend favorable consideration of Senate bill S. 86 at the earliest practicable date.

That completes my statement, Mr. Chairman.

Mr. RHODES. Are there any questions?

Mr. LOSER. Mr. Chairman, I have this one. I note on page 2 at the bottom of your statement you refer to statements made by Senator Lyndon B. Johnson and Dr. Edward Teller. Do you have those statements?

Mr. ORVILLE. I do have them and I can read the statement by Senator Johnson.

Mr. LOSER. I wouldn't care for you to read it, but I do want to ask the chairman's consent that it be inserted into the record.

Mr. RHODES. Without objection, it will be done.

(The statements referred to follow:)

INFORMATION SHEET FOR THE PRESS

Today the Chairman of the Advisory Committee on Weather Control, Capt. Howard T. Orville, United States Navy (retired), suggested that the following questions and answers would provide background for the press release issued today by the committee.

1. What is the Advisory Committee on Weather Control?

It is a small, temporary Federal agency. The committee itself is composed of 5 members from private life in the fields of science, agriculture, and business and 6 members from interested Government departments and agencies.

2. How was the Advisory Committee created?

In 1951 Senator Case of South Dakota, Senator Anderson, of New Mexico, and Senator O'Mahoney, of Wyoming, introduced bills calling for a Federal look into rainmaking or whether modification. The Senate held extensive hearings and, in 1952, Senator Case introduced a bill to create the Advisory Committee. The Congress passed this bill in 1953 and it was signed into law by President Eisenhower August 13, 1953. On December 9, 1953, the President appointed the members from private life and on December 18, the chairman called the members to their first meeting. The committee received its first appropriated funds on July 1, 1954. During the first 6 months it carried out preliminary studies, took a number of field trips, and called a number of conferences with scientists familiar with the field. By January 3, 1955, it had determined on its approach to the problem and had selected and put to work a competent staff.

3. Why was the Committee created?

Some early experiments, sponsored by the Government and by private groups, showed that man could modify clouds and initiate precipitation, with dry ice or silver iodide, under certain circumstances. This was found out in 1946 in the United States and confirmed in Australia in 1947. Some persons quite suddenly jumped to the conclusion that this might revolutionize the weather of the world. Several commercial concerns began selling their services as cloud seeders, carrying out experiments but holding out the promise that these would produce impressive increases in precipitation. Other persons expressed skepticism about the whole business. The subject became highly controversial, among scientists and among farmers, ranchers, and other water users.

Seeking to settle the controversy, the Congress established the Advisory Committtee, and in support of its request for its first appropriation, Senator Case said:

"If the Advisory Committee finds that weather modification experiments cannot produce important results, it will so report and thus deter farmers and ranchers from spending their money unwisely. This will, if such a report has to be made, save the public millions of dollars.

"If the Advisory Committee finds that weather modification activities work only in certain circumstances, it will find out what those circumstances are and thus encourage feasible projects and discourage those which are not feasible.

"If the Advisory Committee finds out it can confirm the results claimed by the reports it has so far received from reputable and scientifically competent operators—increases of from 7 to 50 percent and more—then the dollar benefits to agriculture, industry, and government will be so great as to be incalculable."

4. And what has the Committee found?

It has found through its statistical evaluation that cloud seeding, by means of commercial technique which involves releasing into the atmosphere silver iodide smoke from ground generators produces results which are significant on the west coast. Average increases in storms seeded amount to 10 to 15 percent over that which would have fallen from natural sources.

5. Are precipitation increases of this magnitude (10 to 15 percent) economically important?

An economic study conducted under the supervision of A. M. Eberle, dean of agriculture of South Dakota State College and vice chairman of the Committee, showed that a 1 percent increase during the crop-growing season could pay for the costs of a cloud-seeding operation. Cloud seeding with the use of ground generators releasing silver iodide is inexpensive compared to the value of water apparently obtained. Utility organizations in the Pacific coast area seem to have no doubts as to the value of the precipitation increases they get.

6. Can cloud seeding supress hail?

Cloud seeding to suppress hail looks hopeful though conclusive statistics are entirely lacking up to the present time. Theoretically cloud seeding of a potential hail-producing storm should initiate rain before it has developed into a hail shower. Research on hailstorms is urgently needed and is being recommended by the Committee.

7. Can cloud seeding inhibit lightning?

The severe storm conditions which produce hail are often those which produce lightning. Very possibly the same methods for stopping hail can also stop lightning. Lightning, of course, is one of two principal causes of forest fires and, understanding this, the Department of Agriculture has initiated a research project in Idaho and Montana called Project Skyfire. The Advisory Committee on Weather Control has cooperated with the group carrying out this project.

8. Have A-bomb explosions modified weather?

The language of the law setting up the Advisory Committee (Public Law 256, 83d Cong.) states that the Committee shall "study and evaluate public and private experiments designed to modify weather." An atomic-bomb explosion is not an attempt to modify weather and that is not a concern of the Committee, strictly speaking. However, the Committee has an interest in all activities which may affect or modify weather, first, because of the general concern that all citizens should have over weather factors and, second, because they may suggest ways in which man may affect weather to his benefit. The Chair-

man of the Committee has, therefore, appointed a panel of outstanding experts, including a member of the Atomic Energy Commission, to study this question. It has made a report which does not support the theory that the test explosions have significantly affected the weather, harmfully or otherwise. The question is complex and difficult and the evidence fragmentary. The Committee feels the subject warrants further and continued study and is so recommending in its final report which will be issued December 31, 1957.

9. Does the Federal Government regulate cloud seeders?

The Federal Government does not regulate cloud seeders but the law creating the Advisory Committee on Weather Control specifies that they shall submit reports on their operations—so that the Government, through the Advisory Committee, can keep track of and evaluate their operations in the public interests. The Committee does not now recommend that the Federal Government further regulate the cloud seeders other than to continue to obtain such information.

10. What about the future of weather modification?

The Committee has found (*a*) average precipitation increases of from 10 to 15 percent in one area of this country and (*b*) an apparent decrease in hail frequency in at least one area. These findings do not set limits on the possibilities for weather modification; instead they now establish a firm basis for accelerated research which will most likely lead to a greater degree of control over the atmosphere.

The Federal Government is in a position to promote and accelerate weather modification research developments which may prove of commanding importance to every citizen. It can do this by (*a*) continued surveillance and evaluation of efforts in the field, (*b*) carrying out practical experiments to improve presently known techniques and (*c*) encouraging and supporting basic research. The committee's final report advocates a research effort on a much greater scale than at present.

11. Will it be possible to eventually control weather?

If we accept the opinions of several of our leading scientists in the United States the answer is "yes".

Dr. Edward Teller in recent hearings before the Senate Military Preparedness Committee in elaborating on the danger we face unless something is done to match Russia's scientific effort, noted that we could become a "second-class power" without a war should Russia succeed in controlling weather to a point where it can produce rain over vast areas of its own territory and deprive us of needed moisture.

He said he was more confident of getting to the moon than changing the weather but the latter "is a possibility. I would not be surprised if (the Russians) accomplished it in 5 years or failed to do it in the next 50."

Dr. Joseph Kaplan, a noted physicist and chairman of the United States National Committee of the International Geophysical Year (IGY) predicts that "ocean levels will rise at least 40 feet and inundate vast areas of the earth in the next 50 or 60 years unless atmospheric temperatures are controlled". He ascribes this temperature rise to man's "tremendous use" of oil and gas.

The late Dr. John von Neumann: "Probably intervention in atmospheric and climatic matters will come in a few decades, and will unfold on a scale difficult to imagine at present".

If an unfriendly nation solves the problem of weather control and gets into the position to control the large-scale weather patterns before we can, the results could be even more disastrous than nuclear warfare. To quote Dr. Henry Houghton: "I shudder to think of the consequences of a prior Russian discovery of a feasible method of weather control. * * * International control of weather modification will be essential to the safety of the world as control of nuclear energy is now. Unless we remain ahead of Russia in meteorology research the prospects for international agreements on weather control will be poor indeed. An unfavorable modification of our climate in guise of a peaceful effort to improve Russia's climate could seriously weaken our economy and ability to resist."

THE IMPACT OF WEATHER CONTROL ON THE COLD WAR, BY CAPT. HOWARD T. ORVILLE, USN (RETIRED)

As much as we dislike it, today we are engaged in a cold war with a nation and its satellites whose leaders are stark realists and who will stop at nothing to achieve their objective—the absolute domination of communism throughout the world. President Eisenhower, in his recent state of the Union message, stated, "The threat to our safety and to the hope of a peaceful world * * * is Communist imperialism."

One way of achieving this goal is by means of a worldwide propaganda campaign to lower the stature of the United States in the eyes of the Western Powers. It may well be assumed that they are constantly searching for new sources of material in waging this campaign.

Only last week when the Army successfully fired the Explorer were we able to partially recover some prestige from the terrific loss sustained when the Russians fired two satellites into space. One is still orbiting around the earth. This experience should have taught us that we must be constantly on the alert for seeking the propaganda advantage over the Soviets.

If you will think back to September 1957 or earlier, you will recall that perhaps not one person in a million would have predicted the successful launching of a satellite that would orbit the globe for months. Fantastic! Unheard of! Impossible!! would have been some of the remarks received.

This, then, is an experience very fresh in our minds and should make us aware of the fact that the impossible may become a reality long before the best scientific or military brains can even envisage such an eventuality. In the past we have been slow in assessing the propaganda value of scientific achievements. Let's hope that the future will see us more clairvoyant.

This brings me to the subject of the discussion today—the impact of weather control on the cold war. Few areas of science have implications so profound to all mankind as the study of the atmosphere and the phenomena which occur in it.

Perhaps it would be appropriate to define the term "weather control." Weather controls means that our knowledge of atmospheric processes has reached the level where we are able to apply manmade techniques to large scale weather patterns to start a chain reaction that will produce known results over a specific portion of the globe for a known period of time. For example, if an unfriendly nation were able to bring about the recurring destructive cold spells that have plagued Florida for the past 2 months, this would be absolute weather control.

Prior to the sputnik era the best scientific opinion was that the day of weather control was perhaps 30 to 60 years away, maybe even longer. When, in 1954, I suggested that with the expenditure of $11 billion over a period of 30 to 40 years we might achieve complete weather control, I was severely criticized by my contemporaries.

Since October 1957 there have been many statements (some far too optimistic) by scientists of world renown. Probably one of the most significant statements was made by Dr. Edward Teller before the Senate Military Preparedness Committee. He stated that he was "more confident of getting to the moon than changing the weather, but the latter is a possibility. I would not be surprised if (the Russians) accomplished it in 5 years or failed to do it in the next 50."

What are some of the methods of achieving weather control? A number of methods have been suggested for bringing about major influences on weather or climate. To date none of them can be called effective methods of weather control because, if applied by any nation, no one knows what would be the resulting action of such drastic intervention on our own country or that of other nations. Until we are able to predict with certainty what will happen when manmade methods are applied, weather control should not be attempted.

USE OF COLORED PIGMENTS (LAMP BLACK)

One method of controlling the weather that has often been mentioned is the large scale use of colored pigments over the polar ice surfaces. It is well known that the persistence of large ice fields is due in part to the fact that ice both reflects sunlight energy and radiates away terrestial energy at even higher rate than land surfaces. If microscopic layers of colored matter were spread on the ice or in the air above it, it would alter the reflection-radiation balance, melt the ice, and change the local climate. Measures that would bring about such a change are technically and economically feasible.

WARMING CAUSED BY INCREASED CARBON DIOXIDE CONTENT

The carbon dioxide that is released to the atmosphere by industry in the burning of coal and oil and their derivatives (most of it during the last generation) may have changed the composition of the atmosphere sufficiently to bring about a general warming of the world's temperature by about 1° Fahrenheit. This warming represents a 2 percent increase in the carbon dioxide content of the air. Studies show that when the amount has increased to 10 percent the icecaps will begin to melt with the resulting rise in the sea level. Coastal cities and areas such as New York and Holland would be inundated.

COOLING CAUSED BY RADIOACTIVE "DUST"

When the volcano Krakatao erupted in 1883 it released an amount of energy by no means exorbitant. If the dust of the eruption had continued to circle the globe at high altitudes for 15 years instead of only 3 years, it would have lowered the world's temperature by 6°. Five such eruptions would have brought another Ice Age. This temperature is only about 15° below the present world's temperature.

Dr. Teller has testified in congressional hearings that if 2,000 H-bombs were to be exploded over a period of 20 years, the "dust" floating around in the stratosphere would be sufficient to cause a cooling to bring on a new Ice Age. This, of course, discounts the possibility that the "dust" might serve as freezing nuclei.

ARTIFICIAL SATELLITES AS PLATFORMS FOR WEATHER CONTROL

Weather satellites equipped with powerful telescopes and television attachments could chart cloud movements, detect the birth of hurricanes or other severe storms, and vastly improve our surveillance of weather patterns.

Dr. Hermann Oberth, of Germany, foresees a gigantic mirror "hung" in space. It would focus the sun's rays as giant magnifying glass at any desired intensity and beam. The sun's rays could light entire cities or other areas safely at night. The heat of the rays might be used to prevent killing frosts over orchards, or melt Atlantic icebergs, open frozen harbors, and probably bring about artificial control of the weather.

Senator Lyndon Johnson of Texas stated recently: "From space, the masters of infinity could have the power to control the earth's weather, to cause drought and flood, to change the tides and raise the level of the sea, to divert the Gulf Stream, and change temperate climates to frigid."

I have read that at least twice in the past 12 months Moscow has boasted of large public works projects that would upset the entire wind circulation pattern of the Northern Hemisphere; conducted numerous nonpublicized but still detectable experiments apparently aimed at finding ways to speed the melting of polar icecaps; and has even offered to join the United States in a project to turn the Arctic Ocean into a sort of warm water lake by melting the polar icecap.

Russia's apparent preoccupation with plans to change the climate of the Northern Hemisphere is easy to understand. The Soviets and their satellites stand to profit more, from an economic standpoint, than any other combination of nations.

The proposal to turn the now frozen Arctic Ocean into a warm water lake came over Moscow radio just 3 days after last Christmas.

A Russian engineer, Arkady Borisovich Markin, proposed that a team of international scientists cooperate in designing a dam to redirect the waters of the Pacific Ocean to relieve the severe cold of the Northern Hemisphere. Such a dam built across the Bering Straits would be fitted with thousands of nuclear energy powered pumps that would pump the warmer waters from the Pacific into the colder Arctic Ocean. At other times the pumps on the Bering Straits would pump the water from the Arctic Ocean to the Pacific, canceling out the Greenland, Labrador, and other cold oceanic streams.

Just how such a plan would work is not clear to me: but if, as Markin states, the dam would raise the temperatures of such cities of New York, London, Berlin, Stockholm, and Vladivostok 11° to 14½°, then the melting of the icecaps and the release of landlocked waters would cause seacoast towns and cities to be flooded by the expected rise in the sea levels. This means that Russia might then enjoy warm water ports and mild temperatures similar to our South Atlantic States, but at the expense of great flooding of the Western nations' coastal areas.

Other great schemes for Russian public works programs to divert the course of several of its rivers from the Arctic Ocean to the Caspian Sea are less dramatic, but might eventually upset the present weather patterns over Siberia, which in time would affect the weather around the Northern Hemisphere.

There are many other methods by which effective weather control may be practiced by an unfriendly nation, but they are too numerous to even mention by name.

A moment's consideration of any of the methods mentioned here today should serve to convince any skeptic that weather control can have frightening and disastrous consequences if any unfriendly nation succeeds in gaining a breakthrough before we do.

This is, I think, what Dr. Teller meant when he recently stated:

"The Russians can conquer us without fighting through a growing scientific and technological preponderance. The Russians may advance so fast in science and leave us so far behind that their way of doing things will be "the way," and there will be nothing we can do about it. Imagine, for instance, a world in which the Russians can control weather on a big scale, where they can change the rainfall over Russia. This might very well influence the rainfall in our country in an adverse manner. What kind of world will it be where they have this new kind of control and we do not?"

Now, what courses of action can we take to get out of our present extremely vulnerable position for future Soviet propaganda attacks in the field of weather control? There are two important steps that must be taken.

First, see that Senate bill S. 86 is passed. Fortunately, through the vision and courage of several Members of Congress, notably, Senator Francis Case, of South Dakota; Senator Clinton Anderson, of New Mexico; Senator Arthur Watkins, of Utah; and Senator Warren Magnuson, of Washington, there is now pending in Congress a bill, S. 86, to set up a permanent research program under the National Science Foundation for an accelerated study in all aspects of atmospheric physics. When this bill, which was originated by Senator Francis Case, is passed and is aggressively implemented it will provide for the urgently needed program in basic and applied research.

Second, there must be an awareness and an appreciation of the valuable service that the United States Weather Bureau is performing today under most stringent circumstances. It is understaffed; much of its equipment is obsolete; research facilities are practically nonexistent; its research program is far below that which it should be during these critical times; and the prospects for getting the funds needed to correct these deficiencies are very poor. Other weather services of the Defense Department dealing primarily with military applications of weather control should be given strongest possible support.

Since weather control is an ideal tool for waging the relentless cold war against the Western Powers, we must not become complacent and we must not be caught as we were when Sputnik I was launched last October.

We must take seriously the truth of Vice President Nixon's statement, "the Kremlin has reaffirmed its goal of world domination by nonmilitary means if possible, and by war if necessary."

Weather control has many important nonmilitary applications and just as many military uses.

Mr. RHODES. The next witness is Mr. Eberle.

STATEMENT OF DEAN A. M. EBERLE, SOUTH DAKOTA STATE COLLEGE, BROOKINGS, S. DAK.

Mr. RHODES. Mr. Eberle is formerly the Vice Chairman of the Advisory Committee on Weather Control and is now the dean of South Dakota State College.

Mr. EBERLE. Mr. Chairman, with your permission, I would like to read my statement, which is not too long.

Mr. RHODES. Proceed.

Mr. EBERLE. My name is A. M. Eberle, dean of agriculture of South Dakota State College, Brookings, S. Dak., past Vice Chairman of the Advisory Committee on Weather Control, chairman of the South Dakota Weather Control Commission.

I have been connected with the college for the past 36 years. I have been connected with weather modification or cloud seeding in South Dakota since 1951 when farmers in my State contracted with private seeders to increase rainfall.

At our institution we evaluated the work of the operators, as best we could and have constantly advised with farmers relative to this important work.

South Dakota had at one time 12 million acres under contract with private cloud seeders. The 4-year summary made by State College of the seeding operations showed a 9-percent increase in rainfall, over that which would have fallen naturally. It was difficult to get a good correlation because all areas did not seed the same length of time. The result would have been higher had the seeding dates been the same for all areas. We were sort of pioneers in this matter of evaluation. Since then the Advisory Committee on Weather Control has developed a better method of evaluation and we feel probably if we had gone back in our records we could have indicated that there would have been a greater than 9-percent increase.

In the Great Plains a considerable number of studies have indicated that, in the case of spring wheat, 1 inch of precipitation, above the 5 to 10 inches, is associated with a yield increase of 1.5 to 3.5 bushels per acre.

We can figure that the ratio of increase in yield to increase in precipitation is 2 to 1 over a base of a minimum of 8 inches, or in other words, 1 inch of rainfall over the minimum will yield 2 bushels of wheat.

Over most of the Great Plains the annual average precipitation is so close to the amount required for growing grain crops that the sizable natural fluctuations in precipitation are of extreme significance. In other words, in South Dakota, we say we have rainfall at the margin. An inch of rain over the margin will give us a good crop and an inch of rain below the margin gives us almost a complete failure. That is why we consider this matter of cloud seeding so important in our State.

All of the cloud seeding has been done in the spring. We are finding that fall seeding also has great possibilities. Increasing the fall rainfall, means storing water in the ground and building up the subsoil moisture. If this is done consistently year after year, it will have a real effect in minimizing any prolonged drought period.

Testimony concerning S. 86 to provide for an experimental research program in cloud modification was heard in the Senate on March 26 and May 13, 1957.

I testified at that time the need for research in weather modification and that S. 86 would make that possible.

There was evidence presented at that time by farmers and ranchers, as well as by representatives of scientific and technical groups, who also were strongly in favor of the passage of the bill. Since that time, events have occurred which serve only to heighten the urgency of getting it passed into law, so that steps can be taken at the national level to explore more fully the vital natural resources of our weather.

Early in 1958, volumes I and II, of the Final Report of the President's Advisory Committee on Weather Control were released to the public. There is no need for me to recapitulate the findings of those

volumes further than to state that statistical and physical evidence was produced that showed the effect of artificial stimulation on cloud structures in specifically delineated conditions.

Evidence, indeed, was of such a caliber as to encourage further basic research in cloud processes and precipitation mechanisms in order that subsequent engineering procedures with regard to weather modification practice can be developed and improved.

The people of South Dakota, always pioneers in this field, have sufficient faith in the ultimate benefits to be derived from such studies that they are continuing in a modest way to sponsor basic research and weather modification field studies through the efforts of the State weather control commission and personnel on the staff at State college.

With the passage of S. 86, South Dakota will be prepared and ready to cooperate with the National Science Foundation.

To quote Dr. Henry Houghton's December 1957 statement to the American Meteorological Society. This, I think, is a very important statement by Dr. Henry Houghton who is the chairman of the meteorology department at MIT, and one of the recognized authorities in this country on weather modification. He says—

> All to often we Americans confuse technological progress with research. Basic research is the search for an understanding of nature's mysteries with no immediate practical application in mind. The life-blood of technological progress is the result of such basic research and we can no longer depend on other countries to supply this vital plasma.
>
> Basic research in meteorology can be justified solely on the economic importance of improved weather forecasting but the possibility of weather control makes it mandatory.

Dr. Houghton also says—

> From the reports now reaching us from many sources it is clear that the Russians have a very large meteorological research effort. Since the beginning of October no one has any question of the scientific ability of the Russians and their meteorological research is first-rate. I shudder to think of the consequences of a prior Russian discovery of a feasible method of weather control.
>
> Fortunately for us and the world, we were first to develop nuclear weapons, even though we had to depend heavily on the basic research done in other countries. International control of weather modification will be as essential to the safety of the world as control of nuclear energy is now. Unless we remain ahead of or abreast of Russia in meteorological research the prospects for international agreements on weather control will be poor indeed. An unfavorable modification of our climate in the guise of a peaceful effort to improve Russia's climate could seriously weaken our economy and our ability to resist.

The Advisory Committee on Weather Control offered a long list of suggested projects, in which I concur. Part of this list includes such important studies as—

(1) a study of solar influences on weather,

(2) the factors that control global circulation,

(3) the factors that control the genesis and dissipation of storms such as hurricanes, tornadoes, blizzards, etc.,

(4) electrification process in clouds,

(5) the role of condensation nuclei and many others.

I believe that S. 86 should be amended to include the following. These recommendations are the results of our conferences in South Dakota with farmers and staffs at the State college.

1. That the research undertaken include basic, applied, and engineering research.

2. That a committee be established by law in the National Science Foundation composed of 5 scientific members and 6 lay people to be an advisory committee to the National Science Foundation.

3. The several Federal agencies should not be members of the committee, but could or should be technical advisers to the committee.

4. The National Science Foundation to be coordinator for all research supported by Federal, or Federal-State appropriations.

With these thoughts in mind, and since the urgency of the situation is now being so generally recognized, I believe my testimony can be brief.

If the United States is to continue as a leading power, we must get answers to many of the queries now facing the cloud physicist, chemist, meteorologist, and student of atmospheric science.

This can only be done by developing a well coordinated program of research, endowing it with adequate financial support, and putting it item by item, into the hands of competent and enthusiastic teams of research workers to carry through. I believe that S. 86, with a few amendments, is the answer to that problem.

That is my statement, Mr. Chairman.

Mr. RHODES. Thank you. Are there any questions?

Mr. BUSH. What method of seeding the clouds have you used?

Mr. EBERLE. Up to this time we have used entirely, would you say, the ground method, using ground generators for seeding the clouds. We did some experimental work with National Guard planes, as we had permission from our Governor, and we used both the jet and high-altitude planes, and we did seed clouds by that method, and that was only a year ago, in the spring, when we had thunderheads and clouds that were susceptible to that program.

Mr. BUSH. What did you use for seeding the clouds?

Mr. EBERLE. At that time we used dry ice.

Mr. BUSH. Has there been anything found that is better than dry ice for seeding the clouds that you know of?

Mr. EBERLE. Outside of silver iodide; no. We do use silver iodide for ground generators and dry ice for airplanes, although, this year, starting on the 15th, we are going to use silver iodide in airplanes.

Mr. BUSH. When you seed the clouds in South Dakota do you control the rainfall that you will get there or do the clouds drift and cause the rain to fall in some other area?

Mr. EBERLE. Well, that is very apt to happen. I think we are learning to seed them so it will fall just about where you would like it to fall, but on some of the experiments on weather control it has shown targets were made and yet it proceeded downwind.

Mr. BUSH. We could use some of that. I was wondering if you could get those clouds to come over to Pennsylvania.

This is a very interesting subject. It is something that is very, very serious and very worthwhile. It is a matter that concerns all of us. This matter of seeding the clouds or of trying to produce moisture for our soil is very important.

Now how about snow? Are you trying to seed the clouds so we can get snowstorms, too?

Mr. EBERLE. We would like to, but our farmers won't approve of it because they have had too much experience now in trying to dig themselves out and in trying to get to town and so forth; and so far we have not done that.

Mr. BUSH. According to my information, snow provides a lot of moisture and is very beneficial to the soil and I was wondering if you had done any experimenting along that line?

Mr. EBERLE. We have. I think one of these times the farmers will consent to let us do that.

Mr. RHODES. Thank you, Dr. Eberle.

STATEMENT OF JACK C. OPPENHEIMER, SOLICITOR'S OFFICE, DEPARTMENT OF THE INTERIOR, WASHINGTON, D. C.

Mr. RHODES. Our next witness is Mr. Jack Oppenheimer, formerly executive secretary of the Advisory Committee on Weather Control. He is now in the solicitor's office of the Department of the Interior.

Mr. OPPENHEIMER. Mr. Chairman, I should like to read a short statement, if I may.

Mr. RHODES. Proceed.

Mr. OPPENHEIMER. Mr. Chairman, my name is Jack C. Oppenheimer.

In view of my service as executive secretary and counsel to the Advisory Committee on Weather Control, I was invited by your committee to testify on this proposed legislation. I shall be happy to furnish information and answer questions which are within my competence and authority.

I should like to state that I am at present an attorney in the Office of the Solicitor of the Department of the Interior. While the Interior Department has no objection to me appearing before your committee on this proposed legislation, my testimony in no way is intended or authorized to reflect the views of the Department of the Interior, and represents only the views of the Advisory Committee on Weather Control as expressed in its official reports or my personal opinion.

Subject to the pleasure of the committee, I should like to make a short statement prior to answering any questions the committee may have. If the record of this hearing does not already include it, I believe it would be helpful to insert the legislative recommendations of the Advisory Committee on Weather Control appearing on pages 26 and 27 of volume I of its final report and appropriate reference to both volumes I and II of the final report of the Advisory Committee on Weather Control, dated December 31, 1957.

LEGISLATIVE RECOMMENDATIONS

In accordance with section 3 of Public Law 256, 83d Congress, as amended (15 U. S. C., sec. 311 note), the Advisory Committee shall make a study and evaluation of weather modification or control activities for the purpose of determining the extent to which the United States Government should experiment with, engage in, or regulate such activities. Section 10 (a) of this act requires the committee to submit reports on its findings and recommendations to the President from time to time, for submission to the Congress. At the earliest possible moment, and not later than June 30, 1958, it must submit a final report on its work as well as recommendations on the advisability of the Federal Government's regulating, by means of licenses or otherwise, those who attempt to engage in activities designed to modify or control the weather. The date for this final report was changed to December 31, 1957, by the Supplemental Appropriation Act for fiscal year 1958.

The committee's investigations suggest that the limitations inherent in the geographical jurisdiction and technical administration of the meager case law

and the few State statutes cannot prevent cloud seeding under the wrong meteorological conditions or by professionally unqualified or poorly equipped operators. The State laws do not contain the authority to cope adequately with the physical and legal problems produced by cloud-seeding activities conducted relatively close to State and National boundaries.

Although it is well aware of these problems, the Advisory Committee on Weather Control believes that the most pressing need is for basic and applied research under scientifically controlled conditions and for a sufficiently long period of time to yield results which can be analyzed and evaluated in the public interest. For this reason, the Advisory Committee recommends the enactment of S. 86, 85th Congress. This legislation authorizes and directs the National Science Foundation to initiate and support a program of study, research, and evaluation in the area of weather modification, in consultation and cooperation with Federal, State, and private agencies.

The National Science Foundation research program should be implemented by substantially the same legal authority given to the Advisory Committee to obtain information. Such action is necessary if the Foundation is to obtain the necessary information from all private and public persons and organizations conducting weather modification activities. The authority of the National Science Foundation to obtain such information under S. 86, if enacted into law, should be clarified and made certain. This is necessary in view of the ambiguity of meaning introduced into section 3 of S. 86 by the language of the appropriation item for the Advisory Committee in the Supplemental Appropriation Act for fiscal year 1958. Authority to obtain information should make explicit the discretionary power of the National Science Foundation to require prior notice of the objectives, times, places, and methods of weather modification activities as well as periodic reports of operations after they are undertaken. Where some States have specific statutory authority or general police power to require such notices and reports, the National Science Foundation should make appropriate cooperative arrangements with these States to obtain the necessary information. (The constitutional framework within which this should be done is discussed, together with other legal and legislative aspects, in the section on the Legal Situation in volume II of this report.)

Consistent with the Advisory Committee's legislative recommendations, a member of the staff of your committee communicated with me with regard to clarifying and making certain that H. 86 contain substantially the same legal authority in one respect given to the Advisory Committee so that the National Science Foundation would be assured of obtaining necessary information for its program of study, research, and evaluation from all private and public persons and organizations conducting weather modification activities.

It was the Advisory Committee's hope that this matter of authority to gather necessary information would require clarification only in the report of your committee without necessitating an amendment and further Senate action after action by the House.

However, after consultation, it was our opinion that the intent and purpose of the Advisory Committee's recommendations would be accomplished with certainty by the elimination of all of the language of section 3 of the bill to the phrase "there is authorized" and the addition of section 9 of the Advisory Committee on Weather Control Act of August 13, 1953 (Public Law 256, 83d Cong.), as amended, by insertion by reference at line 21 of section 2 of the bill or by the inclusion of new language in some other appropriate place.

Both prior to and subsequent to consultation with your staff member on this matter of authority to gather necessary information, I discussed it with legal counsel for the National Science Foundation. It is my understanding informally that these methods of implementing the Advisory Committee's recommendations are in accord generally with the views of the National Science Foundation.

As to the other provisions of the bill, I believe it would be more appropriate to have the views of the National Science Foundation witnesses. I have reference particularly to the relationship of the language in section 2 to the powers granted already by the National Science Foundation Act and to the proposed amendment using provisions of section 9 of the Advisory Committee on Weather Control Act.

That concludes my prepared statement, Mr. Chairman.

Mr. RHODES. Are there any questions?

Thank you, sir.

STATEMENT OF JOHN L. DI SANTO, FIELD DIRECTOR, WATER RESOURCES DEVELOPMENT CORP., DENVER, COLO.

Mr. RHODES. The next witness is Mr. John L. Di Santo, field director, Water Resources Development Corp., weather modification projects, 460 South Broadway, Denver 9, Colo.

You may proceed, Mr. Di Santo.

Mr. DI SANTO. Mr. Chairman, I would like the permission of the committee to read my prepared statement.

Mr. RHODES. Proceed.

Mr. DI SANTO. Also, I would like to state to the committee that Dr. Irving P. Krick, the president of our organization, extends to this committee his sincere regrets for his inability to be here and he has submitted a letter to the clerk of the committee which he asks to be included in the record.

Mr. RHODES. Without objection, it will be done.

(The letter referred to follows:)

WATER RESOURCES DEVELOPMENT CORP.,
Denver, Colo., March 12, 1958.

Mr. W. E. WILLIAMSON,
Clerk, Committee on Interstate and Foreign Commerce,
House Office Building, Washington, D. C.

DEAR MR. WILLIAMSON: I regret to inform you that prior commitments will not permit my personal attendance in Washington on Tuesday, March 18, 1958, to testify before the Subcommittee on Health and Science regarding S. 86.

However, our corporation has prepared a statement of policy relative to bill S. 86, five copies of which are enclosed. Our Mr. J. L. Di Santo will be in Washington to present this testimony on behalf of our corporation.

I should consider it a favor if you would introduce this letter as a summary statement of my personal beliefs concerning weather modification, or its ultimate evolvement into weather control. Briefly, they are as follows:

1. Weather modification and weather control shall, in the next few years, be universally recognized as a science.

2. The physical application of this science will greatly assist mankind in the betterment of his environment and personal economic position. It will aid in the elimination of unrest attached to low living standards.

3. The Nation that first acquires control of the weather shall be the leading power in our world. This position could be accomplished in a relatively short period of time and, unfortunately, could be going on undetected. In other words, world invasion could be activated and maintained without the detection by the defensive nations until too late.

4. It is imperative that our country win this race.

5. Private enterprise and courage and faith of the individual American has progressed this science to its present level. This has been achieved in spite of heavy and hindering pressures of negative attitudes prominently displayed by governmental bureaus and some groups at college and university levels.

6. It is not only important but it is a must that this legislation, if passed, receive careful attention and implementation. Heavy responsibilities, the safety

of our Nation depends upon due consideration and mature judgment in the administration of this vital work.

7. There are many groups within our country today that will advocate heavy, basic research with little or no attention to the equally important applied engineering phases of the problem. Where would we be today if we had continued basic research on automobiles, aircraft, etc., say for 20 years before producing a model car. I stress we need an accelerated well-balanced program, including the actual field operational work if we are to proceed upon a sound, logical, and developmental trend that will insure that we find the answers first.

8. Basic research is necessary but again I stress the importance of the other phases. For instance, during the last 15 years we have been engaged in a missile race. We have found that all the laboratory and basic research work means little if the missile won't get off the ground. We are now engaged, by testing—trial and error—in discovering the flaws and how to correct such problems. This is true in any field of endeavor wherein we try to push our frontiers of knowledge forward.

9. I strongly recommend that those groups that have experience in this field, and I refer to the private operators, must be given due and proper consideration in the chance to participate in the funds that will be available under this legislation. Let's not channel into a restrictive field—either private, governmental, or college level.

10. I recommend that a committee or board be set up within the National Science Foundation to administer this appropriation. It should be composed of scientists and laymen, with no members from governmental agencies or private operators.

11. Above all, let us not lose time—and I speak of this advisedly. We do not want this important work pushed back into the laboratories for 10 years to rehash all that has been done—just for the mere satisfaction of scientists with negative attitudes. Time is precious and should not be wantonly wasted.

I respectfully submit all the foregoing as my true beliefs and feelings. I thank the committee for this opportunity of presenting my views and sincerely regret that I could not change my schedule to personally appear.

Sincerely yours,

IRVING P. KRICK.

Mr. DI SANTO. First, Mr. Chairman, may I express my own thanks and appreciation for this privilege of appearing before you.

My name is John L. Di Santo and I am field director of the Water Resources Development Corp., a private enterprise organization actively engaged in the operation of weather modification programs throughout the world.

INTRODUCTION

Mr. Chairman and members of the committee, during the relatively short time that our great country has been in existence, we have been singularly blessed with men and women of vision, courage, and inventiveness. Starting with the Declaration of Independence in 1776 to this year of 1958, which is only a very short 182 years compared to the history of other nations, our country has progressed from an undeveloped group of 13 Colonies to the greatest industrial power in the world. These blessings have come to us because of our unbounded faith in God and in our willingness to put our trust entirely in Him, combined with our own desire of accomplishment.

This great development required, first of all, men and women who were able to project their vision into the future and plan a system of free and democratic government that would guarantee this development.

Second, it required men and women of courage to come from civilization to the uncivilized New World. In spite of the ridicule and unbelief on the part of the majority of the world that our democracy

would not work and would soon disappear, they had the determination to forge ahead and make it work.

Third, it required men and women of inventiveness who were not afraid to come to grips with scientific problems which would result in obtaining for our people the high standards of productivity and the abundance of living which has now become the goal of the entire world.

These men and women of vision, courage and inventiveness have included people from all walks and stations of life and their numbers are legion. They did not come from one class or group, but rather represent a complete cross-section of our free and democratic people.

Our accomplishments have been the result of cooperative efforts of Government, business, labor, and agriculture, operating under a system of free enterprise. The individual has the freedom to develop such ideas, theories, beliefs, or projects as he may desire. Government has not promulgated edicts to prevent him from this development but instead in many instances when the public welfare is involved, has assisted and encouraged him both morally and financially.

The Congress of the United States has been called on many times in the past and is being called upon today to render such assistance. This great body, representative of all of our people, has analyzed and digested the facts in many situations which involve the welfare of our people.

Here, also, as in any walk of our national life, men and women of vision and courage have risen to the occasion. These representatives of the people, without personal gain to themselves, have set aside political differences to champion the progression of a new science which may produce unheard-of benefits to the people of our country and possibly to the world.

The people of the United States would be remiss indeed if we did not pay tribute to their foresight and courage. First of all, to the four Senators who are sponsoring this legislation: Senator Francis Case of South Dakota, of whom, with other South Dakotans, I am especially proud, Senator Magnuson of Washington, Senator Anderson of New Mexico, and Senator Watkins of Utah, as well as to Senator Alan Bible and his committee for their excellent conduct of the Senate hearings last year.

Secondly, to the four Congressmen, also sponsoring this legislation: Congressman Hull of Missouri, Congressman Engle of California, Congressman Baring of Nevada, and to Congressman E. Y. Berry of South Dakota, my own Congressman from my own district in whom we in South Dakota have great confidence, and to you, Mr. Chairman, and to the members of this committee for your patience and kindness during these hearings.

I would also like to extend my appreciation for the appearance of one of our most capable Congressmen from the State of South Dakota, this morning, Congressman George McGovern of the State of South Dakota.

THE PAST

The Congress of the United States is now called upon to consider the further progression of a new science called weather modification and control. The scope of this program is ably outlined in Senate

bill 86. It is necessary that the United States accelerate the development of this science as rapidly as possible. We heartily endorse this view. However, we would like to present some suggestions for the careful consideration of this committee. In order to clarify these suggestions, it is necessary to review some of the history in connection with this program.

1. The first discoveries were made in the laboratories of the General Electric Corp., a private corporation, by Schaeffer, Vonnegut, and Langmuir.

2. These discoveries were engineered by private corporations for direct application in the field.

3. Thousands of farmers, ranchers, as well as private power companies, cities, and other private groups have contributed many dollars to the progress of this science over the past 10 years.

4. During these 10 years these private groups have taken a positive approach to the solution of some of the many problems in connection with this science.

5. During the same 10 years many of the Government agencies have taken a negative attitude. They have been conspicuous for their ridicule and unbelief.

6. These Government agencies have also been conspicuous for their utter lack of any constructive contributions of a positive nature.

7. The Congress of the United States, on the other hand, decided to provide for analysis and evaluation of the results obtained from weather modification operations by passing legislation in August of 1953 to establish an Advisory Committee on Weather Control.

8. This Committee, under the very capable Chairman Howard T. Orville and Vice Chairman Dean A. M. Eberle, has recently completed its report and presented the same to the President and Congress of the United States.

9. The same Government agencies who have ridiculed this program of weather modification have also stated their opposition to the continuance of the Advisory Committee on Weather Control.

10. The Advisory Committee on Weather Control—

(*a*) Made exhaustive analysis of operations conducted by private and public groups in the United States.

(*b*) Conducted physical evaluations of certain phases which have contributed a great deal of seriously needed information and data.

(*c*) Visited and met with agricultural and industrial groups throughout the United States.

(*d*) Analyzed the legal implications in this program.

(*e*) Approached this program, in spite of the direct and indirect opposition of some Government agencies, objectively and with determination to present to the Congress and the people an unbiased, frank, and honest report.

(*f*) Secured access to all the records, methods, equipment, and procedures of the private operators who have always offered their complete cooperation.

(*g*) Found indications of a positive nature in the area of increasing rainfall which more than justify the further development of this science.

11. The final report of this Advisory Committee and particularly the recommendations made in each section should become the starting place for all future research.

12. Private groups and private operators have again moved forward toward new phases of this science. These include—

(*a*) Hail suppression.

(*b*) Lightning suppression.

(*c*) Preliminary steps toward fog dispersal.

Again, ridicule and unbelief are being expressed about these new developments.

13. There were many mistakes made during the past 10 years by the private operators and groups and we are the first to admit them. Overenthusiasm to a certain degree contributed largely to these mistakes. However, with the publication of the first report of the Advisory Committee all groups adopted policies in line with these findings. Without bureaucratic methods the true perspective was set in focus. I might say, parenthetically, if the Advisory Committee had done nothing else, this, of itself, was of vital importance to the country.

14. Continuing changes in techniques and equipment are being made by the private operators to improve the results and to extend our knowledge. For example, our own organization has reengineered its ground-based generating equipment 17 times in the past 10 years and is now in the process of engineering a new model 18.

All of these changes and improvements were made entirely at the expense of the private operator. No assistance was given by any Government agency, either financially, technically, or in any other manner.

15. There are many other developments that could have been undertaken, but the private operators have been limited by the amount of capital they could spend. Their spending is controlled by their dollar volume. We know that many good potentially productive theories and ideas are being delayed because of lack of finances.

16. The accusation has been made that private operators have made "millions" from weather modification operations. It is a fact, however, that practically all of these firms have been and are struggling to make ends meet and to stay in business. Research expenditures are so heavy in addition to operating costs that profits had to be foregone.

17. Private operators and groups have realized the necessity of regulatory actions to protect the general public, and have of their own free will advocated and assisted in the introduction and passage of such legislation in 13 States. In practically every State where weather modification programs were organized, the private operators have urged the people in those States to institute such legislation. State weather control commissions, wherever established, have also been advised to utilize existing technical assistance from the universities, colleges, and even from the very agencies who have ridiculed this program.

18. The private operators have also recommended to their clients that they secure the services of independent evaluators, even using those who have been antagonistic to the program.

19. The private operators have not tried to "gouge" the people using this service, but to the contrary have kept prices at a ridiculously low level.

THE PRESENT

The science of weather modification and control has now reached the stage where accelerated development is not only possible but

necessary. This is true, not only domestically but internationally. The advances made in Australia, just to mention only one of the nations, indicate that highly important discoveries are in the immediate offing. You are, undoubtedly, familiar with some of the plans which have been reported in the press for the development of weather control by the Russians.

The economic benefits to our Nation as well as to the other nations of the world through weather control would far surpass any other scientific development in the history of mankind.

Think, if you will, of the tremendous economic implications of (1) potential elimination of droughts; (2) potential elimination of destructive elements such as hail, hurricanes, tornadoes, cyclones, et cetera; (3) fog dispersal; (4) lightning suppression—and many others.

It is hardly necessary for me to dwell on the military implications. I am confident you are well aware of the potential uses that can be made of weather control by an enemy power. It is our fervent prayer that this Congress will make it possible for our country to get there first.

The instrument which will help us get there first is in your hands, and bears the identification of Senate bill 86. This bill, which has already passed the Senate, is now to be considered by the House of Representatives and is at present in the responsible hands of this committee.

Those of us who have carried on this tremendous task during the past 10 years are determined that our country shall be first, and will continue to work toward that end. However, we need your help. We are not quacks or witch doctors. Our ranks include many of the most highly trained and experienced scientists in the world. These scientists have elected to apply their knowledge and skills through employment with free private enterprise. They are not subsidized by anyone, but believe in the free-enterprise system and prefer to work for private enterprise.

These scientists are not asking you for a subsidy, but are requesting that their skills, knowledge, and experience in the field of weather modification and control be utilized in the conduct of future researches planned under S. 86.

These scientists also feel that all research should start from the level which has already been attained during the past 10 years. Ignoring the development of the past 10 years and starting over again is a complete waste of the thousands of dollars expended during this period by the farmers, ranchers, industrial concerns, cities, and the private operators who have carried on this work. This duplication also means additional cost to our Government and, in turn, to the taxpayer.

It is also vitally important that a positive approach to the problem of both basic and applied research in the field of weather modification and control be taken by the agency charged with the administration of this bill. Applied research must not be sacrificed. Provision should be made for immediate translation of the findings of basic research into engineering methods of application. Improvement of present techniques, methods, materials, and equipment should become an essential part of the overall research program.

SUGGESTIONS

In order to provide a research program that will produce effective and immediate results, we respectfully submit, for careful consideration by the committee, the following:

1. The scope of research should be defined to include basic, applied, and engineering research.

2. The National Science Foundation should be required to establish a Committee on Weather Control composed of 6 scientific members and 5 lay members. None of these committee members shall represent a Government agency or a commercial operator.

3. The various Government agencies concerned with this program shall be designated as technical advisers to the Committee for Weather Control.

4. The commercial operators shall also be designated as technical advisers to the Committee on Weather Control.

5. The Committee on Weather Control shall be responsible for the coordination of all research activities.

6. The bill should provide a method of giving financial assistance to organized groups of farmers, industrial organizations, municipalities, and others who have been or are now conducting scientific weather-modification activities. I would like to clarify that by adding "for research purposes only, not for operations."

7. The National Science Foundation and its Committee on Weather Control shall be instructed to utilize the knowledge, skill, and experience of the private operators in the development and conduct of such research.

Mr. Chairman and members of the committee, I have pointed out earlier that our accomplishments have been the result of cooperative efforts of Government, business, labor, and agriculture under a system of free enterprise. Let us keep this highly successful formula as the bulwark of our Nation.

Let us pass this monumental heritage on to our children, even as our forefathers passed it on to us. To work cooperatively in the interest of our people is a fundamental principle of our democracy. Under our form of government, all groups, whether they be workers, farmers, financiers, industrialists, scientists, or government agencies, are servants of all the people. It is not necessary under our free government to develop any ruling classes or "new classes." We are all part of the whole, and the whole is part of us.

Mr. RHODES. We appreciate your very fine statement, Mr. Di Santo. Any questions?

Mr. BUSH. I would like to ask him this question: Have you had much experience with work that has been done to produce rain in these various areas?

Mr. DI SANTO. Yes, sir; I have been part of many, many projects in the United States. I am not a meteorologist, but I have watched the operation of all of these projects in the country, as well as in Canada and Mexico.

Mr. BUSH. Do you find that some of the clouds which they seed in trying to get rain are dry clouds and you do not get moisture?

Mr. DI SANTO. In the early days, we seeded all types of clouds because we were still learning. As we progressed and I began to analyze

the effective results and the effective levels, we began to discriminate in the choice of the type of cloud that would produce the best results. That is why in the past 3 years the results have been much more significant than in the first 7 years. We learned to crawl before we started to walk.

Mr. BUSH. That was a very fine statement. Thank you.

Mr. NEAL. Mr. Di Santo, your organization is a private organization?

Mr. DI SANTO. Yes, sir.

Mr. NEAL. Would you mind giving us some details, say, as to how you conduct your business, where your sources of income are derived, and so on?

Mr. DI SANTO. I would be happy to. Our organization is, in my opinion, the world's largest weather organization. We operate not only in the United States but, at the present time, we are operating in 13 foreign countries, including Canada and Mexico. Our organization operates in several fields in connection with weather. The oldest part of our organization, which is some 28 years old, is in the business of providing long-range weather forecasts to private industrial corporations throughout the world. That has been our main business for 28 years.

Secondly, we have developed certain instruments such as rain gages, weather guides, weather casters, that we will sell on a private basis.

Third, we have operated for the past 10 years in the field of weather modification as another branch of our activities.

Fourth, we maintain, and insist on maintaining on a research organization, a nonprofit research organization, the American Institute of Aerological Research, which is constantly researching problems on weather.

These are our sources of income, entirely from private enterprise all the way through.

I might say that we have established in Denver, Colo., the world's largest commercial meteorological laboratory. We are now utilizing the Remington Rand Univac 120 for high-speed computation in making long-range forecasts and the progression we have made indicates, and we have told our customers this, and we are doing it, that we will be able to forecast a year or more in advance, fairly accurately as we progress our further researches in this field.

Mr. NEAL. Has your information along those lines always been available to the Government at any time?

Mr. DI SANTO. At any time that a Government agency has requested information from us, we have gone out of our way to volunteer everything they want. I think Captain Orville, of the Advisory Committee on Weather Control, can testify that anything they wanted he gave them.

In one of their projects "Project overseed" they asked us for the loan of our equipment and fuel. We not only gave them the equipment and fuel, but we sent our own man up there to show them how to operate it and conduct it at no cost to the Government whatever. We still are willing to supply any information to the Government that is necessary to the Government. We are not willing to supply information, that may be passed on to our competitors, to the Government. And that is only natural.

Mr. NEAL. May I ask you this one other question? This bill, as I understand it, would provide $1 million a year over a 5-year period. It is largely allocated for research. Now I appreciate very much the emphasis you placed on the development of scientific knowledge and private industry's contributions to that end.

I think that is very commendable.

Now with respect to the appropriated moneys to the National Science Foundation, in your opinion should it be largely devoted to purposes of pure research, basic research, or to what extent would you say that money should be allocated to the various private institutions and colleges for basic research and to field personnel engaged in practical observations?

Mr. DI SANTO. Well, Congressman Neal, to attempt to divide the distribution of $1 million is rather a difficult problem for me; but I can answer it this way, that I think the program needs, first of all, some basic research into the phenomenon that we are not familiar with and certainly that is essential and necessary.

Part of the funds, I think a larger part of the funds should go toward this basic research which is so necessary.

Mr. NEAL. Which naturally means that the basic research laboratories should have it.

Mr. DI SANTO. Basis research is not limited only to the laboratory. There is tremendous basic research that can be done in the field.

For example, one part of it, the study of the distribution of nuclei in the atmosphere, natural nuclei and the effect of additional nuclei in the air, this is a field basic research job which is not done in the laboratory at all. It is done right out in the field. You fly up into the clouds and you take samples of the nuclei and you take counts, you analyze their composition, and you then release additional silver iodide or other nuclei into the atmosphere and determine what happens.

Even the study of the mechanisms of developing rain drops is a job that can be best done out in the field where you are studying right with nature.

When you create laboratory conditions, it is a good thing. I am not criticizing it.

But there is no comparison with the creation of a simulated laboratory situation with this tremendous laboratory outside, which is the biggest laboratory on the face of the earth and that is the laboratory we should be using; so we do want to get away from strictly laboratory research.

It is true we need laboratory research, but we also need field research. You take, for example, I examined the last quarterly report of the National Science Foundation distribution of funds for various researches all over the United States, all over the 48 States, and in this whole report I do not find one commercial organization that had been given any assignment for any research.

It is strictly limited to colleges and universities and societies and meetings and so on.

We have no objection to that. We need this college research and we need these society groups, but there are people in commerce who can contribute a great deal to the researches of this country and they should be given some of the problems to solve. It is the principle of

having a cooperative effort combining all of our knowledge together to solve this problem of weather control.

Mr. NEAL. I take it you assume that a great deal of success for administration of this bill, if it passes, will depend on the ability and the extent to which your advisory committee works harmoniously with the National Science Foundation, is that right?

Mr. DI SANTO. It will depend entirely upon the pulling together by the National Science Foundation, through its committee and all the groups in the United States who are interested in this program and who have developed along these lines, for them to sit down at a table and to work out a program that will solve these problems utilizing all the brains we have instead of just the brains of one Government agency, not that I minimize them.

But what are you going to do when the head of a Bureau calls all of the people who have been in this program for the past 7 years, who are just amateurs and misrepresented operators. What competence can we have? Yet when the final report is drawn and the projects evaluated, the projects evaluated were the projects evaluated by these so-called hit-and-miss amateurs.

I give you one other example, Mr. Neal. I will read to you from the advisory committee report from a statement by Herbert C. Tom to the effect that dry ice seeding has very limited results and is now recognized.

I will read the following:

> The Weather Bureau also conducted an extensive experiment in cloud seeding, using dry ice in the winters of 1952 and 1954 in western Washington State as part of an ACN project.

We sent recommendations in relation to that project asking them to use ground generators as well as air and to use silver iodide as well as dry ice. No attention was paid to it.

Now listen to this:

> The trials were not exclusively on "oreographic clouds" although such clouds * * * the final results of this experiment have not yet been published.

How long do we have to wait, 10 years, before they tell us what happened here? Do we have to wait 10 years for them to write a report on a project that was completed in 1954?

That is the kind of thing [indicating] that I think if we could get together and bring all the brains together and develop projects which would make some sense and we could get reports out now, not 10 years later, we might get somewhere.

Mr. NEAL. Do you think an advisory committee could help bring that about?

Mr. DI SANTO. Yes, sir.

We were very happy to have an advisory committee on weather control because it was not tied to any Government agency. It was a dynamic agency. It set out to do the job with a positive attitude even with the limitations it had. Yet, last year when the bill was originally written, it was written to provide for a continuation of the Advisory Committee on Weather Control.

This committee was taken out of the bill on the ground that it was a temporary committee and that it should be the job that could better be done by a permanent Government agency.

Mr. Chairman, if I were to do it over again, I would recommend that we make the Advisory Committee on Weather Control a permanent agency operating around the same basis as the AEC, then we would get some work done in this field.

We have spent every dollar we have to progress this science and we haven't had any help. We have had a negative attitude instead.

Mr. LOSER. Mr. Chairman, will the gentleman yield?

Mr. NEAL. Yes.

Mr. LOSER. I am wondering what Government agency it is that you are making this assault on?

Mr. DI SANTO. I am not making it on any particular Government agency.

Mr. LOSER. Well, it seems to me that you have just about assaulted them all, from what you have said.

Mr. DI SANTO. There is a situation in Government where one Government agency clears with another Government agency, and that is the way it works.

Now, primarily, the United States Weather Bureau is the key agency in the field of weather.

Mr. LOSER. Are you critical of the Weather Bureau?

Mr. DI SANTO. We certainly are.

Mr. LOSER. What have they done that you did not like?

Mr. DI SANTO. The very things we point out in here.

Mr. LOSER. It says on page 2, your suggestion No. 5, "During the same 10 years many of the Government agencies have taken a negative attitude. They have been conspicuous for their ridicule and unbelief."

Mr. DI SANTO. That is right.

Mr. LOSER. Is that criticism also directed to the National Science Foundation?

Mr. DI SANTO. The National Science Foundation has not taken very many positions until recently.

Mr. LOSER. I asked you if you were critical of the National Science Foundation?

Mr. DI SANTO. No, I am not.

Mr. LOSER. I notice on page 6, suggestion No. 6 of your statement, that you suggest that the Government subsidize certain organizations and groups that are conducting scientific weather modification activities.

Mr. DI SANTO. That is not exactly what we mean, Mr. Loser.

Mr. LOSER. Well you say, "the bill should provide a method of giving financial assistance."

Mr. DI SANTO. Right. That is what I mean.

Mr. LOSER. Can you distinguish between "financial assistance" and "subsidizing"?

Mr. DI SANTO. Yes, I do, very definitely.

Mr. LOSER. How do you do that?

Mr. DI SANTO. In this particular instance, we have certain projects that have peculiar problems in their particular areas. They are conducting weather observations. They need some study in connection with that problem. For example, the hail project in western Nebraska. They should get assistance, we think, financial assistance in the development of a research project in that area to solve some of the peculiar problems for that particular area.

We don't mean for you to subsidize them.

Mr. LOSER. Under your suggestion No. 6, wouldn't that include your corporation?

Mr. DI SANTO. No, sir; it would not.

Mr. LOSER. Are you not carrying on scientific weather modification activities?

Mr. DI SANTO. We are, sir; but we are not asking for our own corporation.

Mr. LOSER. I am not suggesting that you are asking for it, but I am saying that under your suggestion No. 6 you would be eligible for it if the bill contained your No. 6 suggestion.

Mr. DI SANTO. No, because we are not specifying the private commercial operator in weather modification.

Mr. LOSER. But you say "and others who have been or are now conducting scientific weather modification activities."

You are now engaged in that activity?

Mr. DI SANTO. We are as a commercial operator.

Mr. LOSER. And you fall in that category?

Mr. DI SANTO. It was not intended in that way, sir, and it is not intended and if the Congressman desires, we will be glad to strike out and others?

Mr. LOSER. I don't have any objection to it at all, Mr. DiSanto.

Mr. DI SANTO. Well, we do not want any subsidy as a private commercial operator. We do not want any subsidy whatsoever, none at all.

Mr. NEAL. You added a few words to that paragraph, did you not? Didn't you limit it by the words "research only?"

Mr. DI SANTO. That is right. I added those words when I was making my presentation.

Mr. RHODES. Who is responsible that no report was made on this project that was completed in 1954?

Mr. DI SANTO. It lies in the department or bureau who conducted that research job.

Mr. RHODES. Do you know who it is?

Mr. DI SANTO. I think it is the United States Weather Bureau.

Mr. RHODES. Thank you.

STATEMENT OF DAVE GRASMICK, CHAIRMAN, NORTH PLATTE VALLEY HAIL SUPPRESSION, INC., MORRILL, NEBR.

Mr. RHODES. Our next witness is Mr. Davis Grasmick, chairman of the North Platte Valley Hail Suppression, Inc., Morrill, Nebr.

You may proceed.

Mr. GRASMICK. Mr. Chairman and members of this committee:

My name is Dave Grasmick. I am a rancher and stock feeder from Morrill, Nebr. I have just recently been elected chairman of the newly created Nebraska State Weather Control Commission.

In the Nebraska State legislative session of 1957, senate bill 540, was passed which provided for the establishment of a State weather control commission. This law provides that the commission shall consist of the director of the department of agriculture and inspection; the dean of the College of Agriculture, University of Nebraska; the director of conservation and survey divisions of the University of Nebraska; and the chairman of the department of physics of the Uni-

versity of Nebraska; and four representatives of the general public appointed by the Governor.

This commission held its first organizational meeting early in February at which time, I was elected chairman.

The law provides for the licensing and evaluations of weather modification operations in the State of Nebraska. You may be interested in learning that since 1950, there have been five areas with rain-increasing programs and one area with hail-suppression programs in the State of Nebraska.

All of these operations have been carried out on a voluntary basis by raising funds from farm to farm and businessmen. This has all been private financing without State or Federal funds involved.

It is my feeling that additional basic and applied resarch is needed to improve and increase the benefits of these operations. However I wish to urge that the progress and investment that has been made over the, past 10 years in this field should be utilized to the maximum in any research program.

I urge passage of bill S. 86. Also, I would like to submit for your consideration the following suggestions:

1. The National Science Foundation provide a neutral and independent committee to administer the program.
2. The National Science Foundation be advised to utilize the experience and knowledge gained to date by all groups.
3. The National Science Foundation aid and assist the groups engaged in such programs.
4. Field operational research is necessary to increase current benefits.
5. I suggest that the National Science Foundation pay special attention to recommendations made by the National Advisory Committee on Weather Control in its final reports.

With much progress being made in modifying the weather—worldwide—I again urge speedy passage of S. 86.

Gentlemen, I wish to thank you for this opportunity to appear before you.

Mr. RHODES. Thank you, Mr. Grasmick.

STATEMENT OF CLIVE OSTENBERG, CHAMBER OF COMMERCE, SCOTTSBLUFF, NEBR.

Mr. RHODES. Our next witness will be Mr. Clive Ostenberg, Chamber of Commerce, Scottsbluff, Nebr.

You may proceed.

Mr. OSTENBERG. Mr. Chairman and members of this committee. My name is Clive S. Ostenberg, farmer, rancher, and cattle feeder from Scottsbluff, Nebr. I am here before this committee representing the North Platte Valley Associated Chamber of Commerce, and the Scottsbluff Chamber of Commerce.

Before I continue I should like to present to this committee a letter directed to Congressman E. Y. Berry, from Mr. Jack Goodwin, secretary of the Scottsbluff Chamber of Commerce. With your permission and the unanimous approval of this committee, I would like to have this letter included in the record of my testimony.

Mr. RHODES. Without objection, it will be done.

(Letter referred to follows:)

CHAMBER OF COMMERCE,
Scottsbluff, Nebr., March 12, 1958.

Congressman E. Y. BERRY,
House Office Building, Washington, D. C.

DEAR CONGRESSMAN BERRY: It is our understanding the Interior and Insular Affairs Committee of the House will hold hearings on Tuesday, March 18, 1958, on the bill, which you cosponsor, to place weather modification research programs under the National Science Foundation and to appropriate the necessary funds for an adequate operation of same.

If this is correct we again urge you to review the resolution and material sent to you last July relative to the passage of S. 86. We definitely believe this legislation is in the interest of the people of this area, and in fact, the entire country since the eventual control, or modification of weather would be a marvelous addition to our way of life and prove extremely beneficial to all.

We even ask you to consider placing our resolution on record in the Congressional Record, if that would in any way enhance the passage of this bill. We are also sending you sufficient mimeographed copies of this letter to enable you to give copies to each member of the committee.

We wish to point out further that we are in favor of "cutting" Federal expenses in many fields of Government operation, as we have indicated to various committees of the House and Senate, dealing with appropriations and projects we felt could be curtailed. In this case, however, this legislation conceivably could bring about an eventual benefit to the country which would increase the national income and productivity to the end that greater monetary benefits would be received, both by the people and by the government through the increased taxes they would be enabled to pay.

For example, it is claimed by the directors of the Valley Hail Suppression, Inc., elimination of hail damage alone, in 1957, in an area comprising approximately 300 square miles, $4 million in crops was saved. If this is multiplied by the total number of square miles in the United States which are subjected to extensive hail damage, it becomes a tremendous sum. Add to this the potential control of drought control of the snowpack, and the many other weather conditions the research may lead to the control of, and you can see why this program is essential and valuable to the entire country.

Sincerely yours,

A. B. GOODWIN, *Secretary-Manager.*

Mr. OSTENBERG. Also, I have a resolution adopted by the Scottsbluff Chamber of Commerce, a copy of which I would like to distribute to this committee.

It appears possible, in the not too distant future, that weather can be controlled. That famous saying of Mark Twain, "Everybody talks about the weather but nobody does anything about it" no longer is true. In many localities something is being done about it.

We the people in the North Platte Valley of eastern Wyoming and western Nebraska, have been "doing" something about the weather for the past 5 years. We are in an area severely damaged by hail every year. An area rated by hail insurance companies as having such a high incidence of hail that many companies will not even assume the risks of insurance.

These extreme insurance rates were an important factors in influencing the decisions of the farmers of our area when it was suggested that an effort be made to seed the clouds in an attempt to minimize the occurrence of hail.

They, and the businessmen of the valley communities, put their money into a "Valley Hail Suppression, Inc." and hired an airplane to seed the clouds with chemicals believed capable of preventing the formation of hail.

How successful this experiment has been is a matter of individual thinking as no scientific basis of evaluation has as yet been accepted

by the United States Weather Bureau or other governmental agencies and there is not complete agreement among those scientists who are working on weather modifications.

One yardstick, however, that can be used, is the willingness of the people themselves to put their money into this type of program.

In the North Platte Valley of Nebraska, we have voluntarily raised money from farmers, ranchers, and businessmen to carry on a hail suppression project for the past five years. Continuous support has been forthcoming from the same people over that period of time.

This is indicative of their belief in the possibilities of weather modification even though they are aware of the fact that our program here is in the experimental stage.

It is our contention that S. 86 should be adopted with provisions for appropriations as follows:

1. Undertake basic, applied, and engineering research.
2. Establish a committee on weather control by law, in the National Science Foundation, composed of 5 scientific members and 6 lay people none of whom shall represent any governmental agency or commercial operators.
3. Those Federal agencies concerned by this bill to act as technical advisers to the committee.
4. Commercial operators also to serve as technical advisers.
5. The National Science Foundation and this committee to provide financial assistance to organized groups which are undertaking their own weather modification projects.

If these provisions are provided, as we think they should be, the Platte Valley Associated Chamber of Commerce believes our location and past interest deserve consideration in that the basic and applied research should be in an area that has high incidence of hail, snow, thundershowers, wind, torrential rain, light rain and sunshine.

The North Platte Valley has all of these. Then, too, it should be in the central part of the United States so that weather researchers have access to it from all parts of the Nation. We are so located.

It should have an existing weather modification experiment in operation. We have had such a project for 5 years and will continue to maintain one.

It should have a weather station. We have that.

In addition, the Great Western Sugar Co. has maintained, for 22 years, complete records as to hail and rainfall over the entire area they serve. These records, the most complete in the United States that we know of, are available for analysis and comparison.

All of these factors should weigh heavily in favor of the North Platte Valley region, but in addition to these, there are other factors to be considered. We have one of the finest airports in the country from which to send up planes, balloons and to take sightings. We have a smog free air with little or no smoke haze. We have good schools, rated the best in Nebraska for the children of staff people to attend.

We have access to recreation areas of the best. The Black Hills of South Dakota, Yellowstone Park, Estes Park, Teton Park are but a few of the recreational areas which are less than a day's drive from here.

We have, on the whole, a pleasant climate in which to live. A 4,000-foot altitude gives cool nights in summer without air conditioning and

warm, but not hot, days. Winters are cold, but as our climatic data proves, we do not have excessive heat or cold, yet have sufficient variation to be healthful and invigorating.

So, in our minds, this area is admirably situated to have such a research program located at the Scottsbluff Municipal Airport where already are located the weather bureau, CAA office, and the headquarters of the weather modification concern employed by the Valley Hail Suppression, Inc.

Resolutions favoring such a location of this research, if created, have been passed by the North Platte Valley Associated Chambers of Commerce and the Scottsbluff Chamber of Commerce. The people of this region will appreciate your consideration of their desires to have it located here.

Thank you.

Mr. RHODES. Thank you very much.

Any questions?

Mr. LOSER. I would like to compliment the chamber of commerce on having this man as a representative come down here and testify before this committee.

Mr. OSTENBERG. Thank you very much.

STATEMENT OF BOYD QUATE, PRESIDENT, WEATHER ENGINEERS, INC., SACRAMENTO, CALIF.

Mr. RHODES. Our next witness is Mr. Boyd Quate, president of Weather Engineers, Inc., Sacramento, Calif.

Mr. QUATE. Mr. Chairman and members of this committee, my name is Boyd E. Quate. I am president of Weather Engineers, Inc., of Sacramento, Calif. We are a private concern, engaged in the business of conducting weather modification operations and we specialize in hail suppression operations.

Gentlemen, the economic losses suffered by nearly all areas of this country as a result of hail is far greater than many people know. Few people realize that in the United States hail is more destructive than tornadoes. More property damage to industrial, residential, and agricultural areas is caused by hail every year than is caused by tornadoes.

In the 10-year period ending in 1953, hail losses of this country averaged in excess of $53 million annually, according to data compiled by the United States Weather Bureau.

Whereas in that same 10-year period, property damage as a result of tornadoes averaged only about $45 million. It is interesting to note that this period includes the recordbreaking tornado year of 1953. This average of tornado caused damage is about 15 percent less than the damage caused by hail.

Also, it is generally agreed that the hundreds of small losses not reported to the United States Weather Bureau together with those for which no estimates of damages can be obtained would materially increase the total hail damage figures.

In 1951, the most disastrous hail year on record, losses totaled $75,432,200. Of this crops suffered damage to the extent of nearly $50 million.

No section of the United States is immune to hailstorms. Although they are more frequent and severe in some sections than in others.

The two States of Delaware and Nevada are fortunate in that their hail losses are the lowest of any of the 48 States. No heavily damaging hailstorms have been reported from these two States, but no other State can claim this distinction.

A book entitled: "Hailstorms of the United States" by Snowden D. Flora, and published by the University of Oklahoma Press in 1956, contains some very good data in regard to the hail damage experienced by the different States. I would like to quote from this book, page 10:

States having the greatest hail damage, 1944–53 (includes damage both to crops and to other property, compiled from records of the U. S. Weather Bureau)

	Damage
Kansas	$101,877,900
Nebraska	67,643,400
Montana	61,225,170
Iowa	60,171,212
North Dakota	34,434,000
Texas	31,858,275
North Carolina	31,715,516
Colorado	31,152,976
Oklahoma	29,256,725
Illinois	10,226,120
Missouri	9,377,450
Minnesota	9,807,800
South Dakota	5,297,100
Tennessee	4,542,000
New Mexico	4,061,100
Arkansas	3,811,700

These are the 16 States having the worst record. Other States suffer severe damage, too, but not on as vast a scale as the above-mentioned States. Fruit, especially apples, peaches, apricots, grapes, pears and plums are easily damaged even by comparatively small hailstones, which can pit and bruise it enough to make it unfit for market. Fruit is the main item of loss from hail damage in California, Washington, Michigan, New York, Pennsylvania, West Virginia, and Virginia.

Also, I invite your attention to the fact that there isn't a crop grown in this country that doesn't suffer damage from hail. Tobacco is particularly susceptible to hail damage. Its broad leaves, extending almost horizontally, break sharply at the stalk when pounded by hail. The leaf itself is delicate and its value is drastically reduced by even a small amount of puncturing and tearing. Hailstorms, occurring throughout most of the growing season, are a constant menace. Cotton, corn, the cereal grains, are all susceptible to hail damage. Even the trees of our wooded areas of this country suffer when severely damaged by hail.

The most damaging hailstorm of record occurred on June 23, 1951, when the one storm caused damage amounting to $13,240,000. This storm struck the area from Sedgwick County to Allen County in Kansas and included the city of Wichita.

During the period of 1944 through 1953, there were an average of six storms per year that caused damage in excess of $1 million. Some of these heavily damaging hailstorms were reported as far south as Florida and as far north as Michigan, Minnesota, North Dakota, and Montana. Storms causing damage in excess of $1 million per

storm have been reported in California in the west and New England in the northeast.

The largest hailstone that was ever officially measured fell on July 6, 1928, at Potter, Nebr. This stone measured 17 inches in circumference and weighed 24 ounces—one pound and a half. This size may be compared to an ordinary grapefruit, which, if my memory serves me right, measures about 10 inches in circumference.

Even our Nation's Capital, Washington, D. C., has suffered heavy loss on occasion as a result of extra large hailstones. On April 29, 1938, hailstones were reported to be 3 inches in diameter. On May 26, 1953, hailstones were reported ranging in size from golf balls to baseballs.

It is inconceivable to us that the public, both agricultural and industrial, will permit hail losses of this magnitude to occur, if science can do something about it. Also, it is our opinion that not only can science do something about it, but that scientific endeavor, on a relatively small scale is doing something about it.

We invite you to consider that all the hail suppression projects that we know of, have been financed locally by the people themselves. No outside or governmental financial support has ever been given. The people with whom we contract with believe that they themselves should finance their own local hail-suppression operations. The problem is theirs and the results obtained will be theirs and theirs alone, as far as the operations are concerned. However, there seems to be a practical limit to which local areas are able to finance their own programs. It has been possible to obtain finances locally in each area to conduct the physical operations, but it has been impossible to obtain finances locally to conduct any extended basic and applied research program.

Most people to whom I have talked seem to believe that it is the responsibility of the local groups to finance their own field operations where they themselves obtain all the benefits. However, for those programs where information must be obtained and where this information will be of benefit to the Nation as a whole, it should be the responsibility of all the people, and should be financed by Federal funds.

We would like to state our support of S. 86 and make the following recommendations: This new science is of such vast importance, both economically and otherwise, to the Nation as a whole, that we believe that the supervision of any research program Congress decides upon should be a full-time job. We recommend that a committee of responsible persons be given complete authority for any and all research programs relating to weather modification and financed by Federal funds. We agree that this committee could serve under the Director of the National Science Foundation, but the Committee members should have no other governmental connection. Their functions will be too important to the Nation as a whole to be doing only a part-time halfway job.

We would also like to recommend that Congress recognize the need for two types of research in this new field. We desperately need more extended basic laboratory research. But also, of equal importance, applied research in the field is needed. We do not believe that the progress will be achieved, and of which the scientists of this

great country of ours are capable of producing, if one type of research is neglected at the expense of the other. Both laboratory and field research is urgently needed.

May I invite your attention to the fact that our good neighbors to the north—Canada—have carried out hail suppression operations for the past 2 years and are now going into the third year. The Canadian Government has appropriated $100,000 each year for a radar research program alone to observe and study the hail suppression operations. We think this is a most commendable action.

In closing, I would like to say that we believe we are making progress in this new science of weather modification, but the Nation needs favorable congressional action for the type of research discussed before this committee today to develop and continue world leadership in this exciting new scientific field.

Gentlemen, it has been an honor to appear before you today.

Thank you.

Mr. RHODES. Thank you, Mr. Quate.

STATEMENT OF WALTER G. SCHREIBER, PRESIDENT, HUDSON VALLEY CROP SERVICES CO-OP, INC., RED HOOK, N. Y.

Mr. RHODES. Our next witness is Mr. Walter G. Schreiber, Hudson Valley Crop Services Co-op, Inc., Red Hook, N. Y.

You may proceed, Mr. Schreiber.

Mr. SCHREIBER. I would like to read into the record two prepared statements, if I may.

I am Walter J. Schreiber, president of Hudson Valley Crop Services Co-op, Inc., which is engaged in a hail prevention program in our valley.

I am also a farmer, primarily a farmer, since I make my living at it or I try to.

During the past 10-year period, since the laboratory experiments in atmospheric physics were conducted by Drs. Langmuir, Schaefer, and Vonnegut at the G. E. Research Laboratory in Schenectady, weather modification techniques have improved and results point to future possibilities of tremendous impact. At least 40 other countries, including Australia, Japan, Switzerland, Russia, Spain, Israel, and Pakistan, have recently or are presently conducting research using the scientific methods proposed by Drs. Langmuir and Schaefer.

In the spring of 1956, subsequent to a year of disastrous hail damage to the crops of the Hudson Valley in New York, a group of men representing some 400 growers in the area met and formed the Hudson Valley Crop Services Co-op, Inc. The purpose of this group was to determine the extent to which hailstorms might be suppressed through weather modification techniques.

A commercial weather modification company was contacted (Weather Modification Co., San Jose, Calif.) and during the summer of that year a field operation was put into action covering a 1,500-square-mile area. The results of the 1956 program looked extremely impressive but not necessarily conclusive. The program was renewed for the following summer of 1957. While this operation was successful on all storms similar to those of the previous season, it resulted in only partial suppression of several high-intensity hailstorms, and

damage to crops was termed excessive. The need for further research, particularly on severe intensity storms, was graphically demonstrated.

The programs covering the 2-year period were financed mainly through voluntary contributions from the growers in the area and in part by donations from business houses. The sincere interest of the growers concerning a serious economic problem is emphasized by the fact that more than $70,000 was voluntarily contributed for these programs.

The need for a continuation of hail suppression work in the Hudson Vaalley is emphasized in two broad fields: (1) the economy of the Hudson Valley and the entire State of New York; (2) the value of resultant information to the entire field of weather modification and indirectly on the overall economy of the United States.

As to the effect on the economy of the Hudson Valley, it should be emphasized that this area alone produces an average annual crop of about 7 million boxes of apples. The value of this varies greatly with marketing problems, but would average between $15 million and $20 million. During the summer of 1957, loss from hail damage to fruit alone was nearly $2 million. Damage to other crops, buildings, and, indirectly, to the entire area was undoubtedly great and produced huge losses impossible to evaluate.

It is important to note that information gained from further programs in the Hudson Valley would be of tremendous benefit to the science of weather modification and result in information usable by other areas throughout the United States. Hail damage throughout the United States, as well as the Hudson Valley, indicates the growing need for further research in this particular phase of weather modification.

There is a great desire on the part of the growers in the Hudson Valley to continue a hail-suppression program, and much serious thinking has been done concerning the future of such a program. However, it does not seem likely that a program designed to answer many of the questions involved in hail suppression can, in the near future, continue to be supported entirely by the voluntary contributions from the growers of the valley.

The experience of 1957 indicates that further research in weather modification is needed. It would require a long-range program to determine the commercial feasibility of hail suppression as one important phase of weather modification, and require funds which the farmers of this area are in no position to spend. The fruitgrowers feel that we wish to pay for our own protective programs, but more knowledge is needed before we can invest $3 to $6 per acre for hail suppression. We would like to be sure that our money will not be wasted. We and other farmers all over the country need to know whether such a program will be economically sound. We seem to have enough, or let's call it adequate, statistical knowledge on weather modification.

This knowledge now needs to be used on an actual rather than on a theoretical basis so that we may have confidence in the commercial application of the ensuing results.

We feel that the proposed legislation allows this opportunity to the National Science Foundation. For such exploration, the Hudson Valley Crop Services Cooperatives, Inc., strongly recommends the enactment of bill S. 86 by this Congress.

Now, I have a further paper which I would like to read here, a statement by Mr. Ralph Smith, who is the president of the New York State Horticulture Society in Rochester, N. Y.

Mr. DINGELL. I wonder if it wouldn't be proper to just have that inserted in the record, because we have so many other witnesses that we would like to have testify for the record. Would you mind just inserting that?

Mr. SCHREIBER. I am satisfied to do that.

Mr. Chairman, I would just like to make one more comment, if I may.

The suggestions that were made by Captain Orville in regard to the four suggested changes in the bill, particularly paragraph 6 of his testimony, which he gave this morning, I would like to endorse that as well as alining myself with Representative McGovern in his statement this morning as regards applied research.

I feel that it is most necessary that we continue, or at least start, to give it a good start, this applied research, and I believe there was other testimony given this morning which we farmers in the valley certainly support. We believe that basic research can lead to a lot of paperwork which will not necessarily manifest itself for years to come, and we believe that field operations as they develop can be immediately applied, and the farmers in this instance would get immediate effect from such a program.

That is the statement I wish to make.

(The statement referred to follows:)

TESTIMONY BY NEW YORK STATE HORTICULTURAL SOCIETY, ROCHESTER, N. Y., RE S. 86, 85TH CONGRESS

DEAR MR. CHAIRMAN: The years of 1956 and 1957 brought to our attention the tremendous importance of weather modification. This impression was created by the hail-suppression project which was then being conducted in the Hudson Valley of New York. Heretofore, to use a cliché, everyone talked about the weather but no one did anything much about it.

It must be obvious to the most skeptical that, if the severity of most of the weather phenomena can be reduced, we will have made tremendous strides toward improvement of our agricultural economy. It must also be obvious that such results are not confined to the benefit of agriculture alone, but also will wield a widespread influence upon the life and economy of our Nation. As our population density increases and as we become more and more mechanized, so will the importance of weather manifest itself. Judging by the results of the Hudson Valley project, and also other projects, we are not sure that it will ever be feasible for man to control weather; but we do not know that the efforts made by the valley fruitgrowers were, at least to a great degree, successful.

Ever since the discoveries of Drs. Langmuir and Schafer we have seen in this country a development of commercial enterprises operating primarily in the field of agriculture, which claim to be able to modify the weather to the satisfaction of their clients. But we claim here that a case only approaching satisfaction has yet to come to our attention. Most programs—particularly those dealing with hail suppression—are short lived. Let us hasten to say here that most companies now operating in this field are doing their conscientious best to do a good job, but with only partial results.

It is our considered opinion that, with the meteorological data now available, programs should be set up—as can be done here in the Hudson Valley—where this knowledge may be applied on a practical basis and where research teams can further develop techniques which can be used by the commercial companies. In this manner we will have actual applied research and still plenty of room for the basic research yet so sorely needed. We believe that, if such practical programs are carried out, farmers and industry will have more confidence in the operations of the weather-modification companies.

The farmers of this Nation cannot underwrite such research. We feel that this is a job for the Federal Government to develop and pass into the hands of farmers and industry so that they may spend their money with confidence.

You have before you bill S. 86, which, in our mind, will provide for the necessary research. We feel, however, that—commendable as this legislation is—we would like to have seen it written with a more positive tone. But, since it is going to be administered by the National Science Foundation, we place our hope and faith in the hands of this able institution. We, therefore, strongly recommend the adoption of this bill at the earliest possible moment.

RALPH R. SMITH, *President.*

Mr. RHODES. Thank you very much.

Those who are listed to testify today and have not answered my call will be permitted to submit their statements for the record. Without objection statements by Mr. Langfitt, Mr. Swackhamer, and Mr. Whitfield will be included.

Our next witness will be Mr. Vonnegut.

STATEMENT OF BERNARD VONNEGUT, ARTHUR D. LITTLE, INC., CAMBRIDGE, MASS.

Mr. RHODES. You may proceed, Mr. Vonnegut.

Mr. VONNEGUT. My name is Bernard Vonnegut. I am a scientist associated with Arthur D. Little, Inc., of Cambridge, Mass.

The development of effective methods for controlling weather would be of such enormous value we cannot afford not to pursue this goal. Therefore, I am wholeheartedly in favor of the intent of Senate bill 86. However, it appears to me as a scientist engaged in weather research that the bill in its present form will largely fail to achieve its desired results because it is based on a false premise.

This false premise is incorporated in the title of the bill—the mistaken assumption that it is possible to define and recognize some kinds of research that may lead to weather control and other kinds which will probably not. I feel there is substantial agreement among my scientific colleagues that the first step that must be taken toward weather control is to enlarge our present very fragmentary understanding of how nature makes weather. Only when we understand this will there be any real chance of our controlling the weather.

I believe we should profit from our past experience. There is little doubt that the greatest step that has been made thus far toward controlling weather was Vincent Schaefer's discovery of cloud seeding. It is worth noting that the experiments leading to this discovery were motivated by no thought of controlling weather but rather the desire to understand how nature works. I feel we should recognize, as the late Irving Langmuir once stated, that we cannot plan research but only provide a favorable climate for it. I believe the best way to achieve weather control will be to sponsor basic research in the physical sciences necessary to the understanding of weather.

I have brought with me a suggestion or a document containing recommendations for a national institute for atmospheric research to be submitted to the Advisory Committee on Weather Control. I would like to have that, if I may, included in the record.

Mr. RHODES. Without objection it will be placed in the record.

(The statement referred to follows:)

Recommendations for a National Institute for Atmospheric Research

By B. Vonnegut and Vincent Schaefer

The importance of weather to our national well-being can scarcely be overestimated. It plays a vital part in our day-to-day personal lives, in our national economy, and in all military operations. The weather is one of the greatest of all the imponderables we face. There appear to be two primary ways that we can cope with the problems posed by the weather. First, we can learn to predict the weather so that we can prepare for it, and second we can learn to control the weather to produce desirable conditions. If we are to predict or control the weather, we must understand far more about it than we do at present. There are large areas of ignorance in the field of atmospheric physics that must be explored before we can make accurate predictions of the weather or control it.

In view of the importance of the weather to our welfare, it is desirable that as a matter of national policy we encourage and promote research in this field on a scale commensurate with its importance. A rough measure of the extent of our present attack on the problems of atmospheric physics can be obtained by comparing the expenditures for research in this field with the annual total national expenditure for research. By rough estimate, we are now devoting less than 0.5 percent of our total research effort toward one of our most pressing problems—the weather. It appears obvious, in view of how important the weather is and how little we know about it, that the present effort is far too small and should be increased.

The establishment of an adequate national program in the field of atmospheric physics will require the following:

1. Competent and imaginative scientific personnel.
2. Financial support.
3. Sound scientific direction and coordination.
4. A flexible organization framework under which the work can be planned and carried out on a long-term basis.

In order to achieve these ends it is urged that the Federal Government take immediate steps to establish an adequate research program in the field of atmospheric physics.

A national institute for atmospheric research should be established. This institute should have the following functions:

1. Have a small permanent force of highly competent research scientists capable of initiating, coordinating, and participating in field and laboratory investigations related to the physics and chemistry of atmospheric processes. From time to time this group should sponsor special field research projects, inviting other research groups to participate in a joint attack on specific problems in basic research.
2. Sponsor research projects in universities, foundations, and private organizations.
3. Select certain local geographic areas for intensive investigations of atmospheric phenomena. These places would be located on the basis of their unique physical features for producing certain effects bearing on important atmospheric problems.
4. Serve as a center for coordinating research in atmospheric physics and chemistry.
5. Encourage the recruiting of capable workers by short-term research studies in existing observatories and other institutions by professors of other disciplines available on sabbatical leave. Proper activity in this category will direct the public's attention to this fascinating and important scientific frontier and thus lead to greater interest on the part of young people toward a career in this field of research.

Because of the complexity of atmospheric phenomena, it is important that the proposed institute have a broad background in the fundamental physical sciences. It is suggested that the overall direction of the institute be in the hands of a board of directors chosen from top-level scientists from many fields, such as physics, chemistry, aerodynamics, biology, and meteorology. These directors will establish policy and appoint a full-time scientific director of the institute. The directors by reason of their diverse interests will insure a well-rounded approach that will cut across the artificial barriers that frequently separate areas of scientific research.

It appears that at the present time the most pressing need is for fundamental knowledge of atmospheric physics and chemistry. Accordingly, it is urged

that the proposed institute be entirely a scientific research organization. It should be unencumbered by other responsibilities, such as weather forecasting, equipment evaluation, or formulating legislative recommendations. It should be the purpose of the institute solely to determine how natural atmospheric processes operate, how they can be predicted, and how they can be modified. The information obtained by this purely scientific group will serve as the necessary foundation for making decisions concerning such practical problems as the possible need for weather-control legislation.

It is by no means intended that the proposed institute would in any way supplant existing work in cloud physics. It would rather be its purpose to aid and stimulate further work in this field and to draw attention to important problems.

Mr. Vonnegut, your statement is a very valuable contribution to support your position.

Mr. DINGELL. May I be permitted to ask Mr. Vonnegut a few questions?

Mr. RHODES. Proceed.

Mr. DINGELL. I was interested in your statement that you urge more basic research and not field operations.

Mr. VONNEGUT. I think much can be learned by field operations, I mean going out and trying, without fully understanding what is going on; but I think there is general agreement amongst scientists that in order to understand what we are doing, and even to be able to do it again, we have to know an awful lot more than we do now. I think our understanding of just what a cloud is, for example, how the air moves in it and how precipitation forms, that this is in terrible shape. In many ways it is as though we were trying to design a supersonic aircraft and just hoping that we would hit upon it without making it necessary to understand, we will say, dynamics or aerodynamics. I think there is certainly room for a more knowledgeable approach and there is a vast foundation that needs to be constructed and this will require continuing work.

In other words, you cannot have a technology of weather control that is independent of any science. In other words, you have to have the science first.

Mr. DINGELL. Would you indicate who Arthur D. Little is?

Mr. VONNEGUT. Yes. Arthur D. Little, Inc., is a firm, a profitmaking organization that engages in a wide variety of different sorts of research efforts for industry and for the Government, too.

Mr. DINGELL. Would you also tell me your educational background, sir.

Mr. VONNEGUT. I am a physical chemist at the Massachusetts Institute of Technology and I received my doctor's degree in physical chemistry in 1939.

Mr. DINGELL. Thank you, sir.

Mr. RHODES. Dr. Wallace E. Howell? Since he is not here they will be permitted to file a statement.

That also includes Dr. James H. Jensen and Dr. Svarre Pettersen and Dr. Glenn E. Stout.

That will conclude the committee hearing. The committee is adjourned.

(The statements which were received are as follows:)

IOWA STATE COLLEGE OF AGRICULTURE AND MECHANIC ARTS,
Ames, Iowa, March 12, 1958.

HOUSE OF REPRESENTATIVES,
COMMITTEE ON INTERSTATE AND FOREIGN COMMERCE,
SUBCOMMITTEE ON HEALTH AND SCIENCE,
House Office Building, Washington, D. C.

GENTLEMEN: Iowa State College would like to go on record as favoring the enactment of S. 86, to provide for research in weather modification.

It is expected that the research program established by this bill would provide a final authoritative answer to very important questions: Can man modify weather in such a manner as to increase or decrease precipitation, suppress hail and lightning, and alter other detrimental weather conditions? If man is able to influence his climate, even on a small scale, it would have a stabilizing effect on the economy of the agricultural and industrial areas of the United States by providing for a more constant water supply.

The research program to be established by the bill is to continue basic research in the field of cloud phsyics and to study natural rain-producing mechanisms in various climatic areas and the effect of weather-modification techniques on these processes. It is important that these mechanisms be studied in areas where no orographic effect is present. Only a properly controlled, carefully designed field experiment conducted over a period of several years will give a definitive answer to what extent precipitation amounts can be modified.

This and other governmental supported programs in weather modification should be carefully coordinated to avoid duplication and to insure that all phases of the program are studied.

Iowa State College would be a willing participant in such a research program.

It will not send a witness to testify before the subcommittee, but this statement presents our opinion for the bill.

Sincerely yours,

JAMES H. JENSEN, *Provost.*

A STATEMENT FOR THE SUBCOMMITTEE ON HEALTH AND SCIENCE OF THE COMMITTEE ON INTERSTATE AND FOREIGN COMMERCE OF THE HOUSE OF REPRESENTATIVES RELATIVE TO S. 86

My name is Glenn E. Stout. I am head of the meteorology section of the Illinois State water survey, Department of Registration and Education, State of Illinois, whose activities are authorized by the board of natural resources and conservation. The water survey which has been in continuous service for 63 years, is responsible for the collection, analysis, and dissemination of facts, concerning water resources in the State of Illinois.

I desire to endorse S. 86, a bill to provide for research in weather modification which was introduced in the 85th Congress and subsequently, amended. It is gratifying to note that the revised bill calls for support of a program of study, research, and evaluation in the field of weather modification, giving particular attention to areas that have experienced floods, drought, hail, lightning, fog, tornadoes, and other weather phenomena.

We are extremely interested in this bill since the weather hazards previously mentioned here occurred with great frequency throughout the Middle West with enormous economic losses resulting from them. It has not always been possible to forecast successfully the occurrences of severe weather due to lack of basic knowledge. Weather modification cannot be efficiently accomplished unless the physical processes are understood. The recent television showing of The Unchained Goddess is an excellent example illustrating some of the forces involved in the production of great storm masses concerning which our knowledge is not complete.

The population density in Illinois and its neighboring States is three times greater than in the Great Plains States. Statistics up to 1950 show that although Illinois ranked 12th in frequency of occurrence of tornadoes, it was first in number of people killed and second in property damage. Thus, the probability of loss of life from tornadoes and other weather extremes is exceptionally high in our State. It is important to design research activities that are applicable to areas of high population and industrial concentration.

United States Weather Bureau records for Illinois during the past 8 years indicate that each year property and crop damages have exceeded $7½ million, excluding flood damage. During 1957 losses from weather phenomena, including

floods, exceeded $43 million. Floods of June 14–15, 1957, in the East St. Louis area and eastward across Illinois caused losses of over $26 million. Records of the Crop-Hail Insurance Association indicate that damage to crops amount to over $1 million each year. In a storm on August 17, 1948, total damage from hail was estimated at over $4 million. These figures for Illinois are only a few that could be quoted to illustrate the magnitude of losses. Yet, only a few dollars are being spent annually on research to understand the initiation and behavior of such storms. One cannot modify the weather until the basic parameters causing it are understood.

HISTORY

Extensive cloud-modification studies began just a decade ago and much credit should be extended to Dr. Langmier, Dr. Schaeffer, and their staff at the General Electric Co. for their findings. Subsequent major projects of the Department of Defense, University of Chicago, New York University, and other organizations have indicated that clouds can be modified, but such studies in the Middle West were handicapped by drought conditions and inadequate aircraft. Consequently, it was not possible to collect sufficient data to accurately define the probabilities of modifying cloud structures and the economical significance of such modification.

In 1948 the State of Illinois recognized the importance of determining the natural conditions of cloud formation and rainfall. Dr. A. M. Buswell, then chief of the Illinois State water survey, presented testimony on House bill 4582 of the 80th Congress which encouraged the use of Federal funds for weather-control studies. A small staff was then organized at the State water survey to develop an understanding of meteorological phenomena pertinent to water resources. Work was initiated to evaluate the progress being made on cloud physics research and dense rain gage networks were established to obtain detailed data on Illinois rainfall. Since that time, considerable knowledge has been gained on the distribution of precipitation and on future research needs.

Through support from the United States Army Signal Engineering Laboratories and the Cambridge Air Force Research Center, a staff of 15 scientists has been engaged by the water survey since 1954 on numerous meteorological studies. The reduction in research funds of the Department of Defense in the summer of 1957 has caused the survey to reduce its meteorological staff by 40 percent.

A few other States, notably Arizona and California, have initiated research programs in cloud physics and cloud seeding. In these few studies financial resources have been limited, and more intensive basic research is needed to expand our knowledge of atmospheric conditions controlling the precipitation process.

BASIC RESEARCH NEEDS

An evaluation of the various studies mentioned in the previous section indicates further research in the fundamentals of cloud physics needs to be undertaken. The known and unknown facts about clouds and rainmaking were summarized in February 1957 by Dr. H. R. Byers, director of cloud physics research, the University of Chicago, in a pamphlet entitled "Cloud Physics and Rainmaking." This pamphlet is recommended for your reading since it has been prepared in nontechnical language for personnel of public utilities, agricultural groups, Government agencies, and others interested in the current status of modifying the weather.

Experiments by the University of Chicago cloud physics project, under sponsorship by the Air Force during 1952–54, and in which the water survey was a subcontractor, indicated that the formation of precipitation in Illinois and much of the Midwest in the summer is frequently initiated by the coalescence process before clouds build to the freezing level. This development in theory is contrary to the general accepted ideas of rain formation by the ice crystal process above the freezing level in this region and is pertinent to cloud modification. The data were quite limited and this work should be continued.

Concurrent with studies on the formation and growth of raindrops, research on the basic physical and dynamical properties in the formation of lightning, hail and tornadoes should be pursued. Detailed field data to determine the characteristics of such storms needs to be collected. The atmosphere needs to be sampled prior to, during, and after the occurrence of these events to ascertain the basic causes for their formation and dissipation. After the natural phe-

nomena are understood, methods to suppress violent storms should be investigated.

REGIONAL INVESTIGATION NEEDS

Studies also made by the University of Chicago indicate a large variation in the cloud dimension characteristics between the Caribbean area, Central United States, and Southwestern United States. In view of the large differences between various geographical regions, it is apparent that cloud physics studies should be undertaken in various parts of the United States.

Droughts occur in all parts of the United States. They are not confined to the arid Southwest or the Great Plains. Deficient rainfall in the Northeast in the late forties caused water restrictions in New York City. Although rainfall in Illinois is often classified as abundant, droughts are not unusual. While a severe drought prevailed in the Southwest part of the United States during 1952–55, the southern half of Illinois experienced a similar drought which caused a crop failure in 1 year, substantial reduction in yield during the other 2 years, and critical shortages in numerous industrial and municipal water systems. A detailed study by the water survey shows that 50 percent of the southern Illinois communities, depending upon surface water supplies, suffered shortages during the 1952–55 drought, and over 10 percent of the public water supplies in the drought region, relying on ground water sources, experienced deficiencies.

Droughts of the early fifties in many regions of the country were followed by major floods on the east coast and west coast. In 1957 floods and wet weather prevailed in the Central and Southeast parts of the country while New England experienced a prolonged drought. The frequency of occurrence of unusual storms varies considerably from one region to another. Consequently, numerous regional studies need to be made. Because of the great variety of climatic conditions in the United States and the complexities of weather, research will be costly.

BENEFITS

The benefits that would be gained by further research in the field of weather modification are numerous. Almost every activity in the United States depends at one time or another upon satisfactory weather conditions. Industry, commerce, agriculture, athletics, and many other activities are confronted with great losses under abnormal weather conditions.

ADMINISTRATION OF RESEARCH

Solving the mysteries of nature is difficult and time consuming. Laboratory models of atmospheric processes have not been built to any great extent because it is hard to reproduce the great complexity of the atmosphere in the laboratory. Studies, laboratory testing, and field experiments need to be designed with great care. Results from meteorological research should not be expected too rapidly. Long-term planning needs to be employed. Capable leadership, sufficient coordination between various groups, and freedom of the scientist to explore ideas are necessary. The National Science Foundation should take the leadership and the Congress should support their request for funds. The millions of dollars spent on research will eventually be compensated for, through reduction in the loss of life, crops, and property damage.

SUMMARY

I wish to heartily endorse the passage of S. 86 and the appropriation of sufficient funds so that study, research, and evaluation in the field of weather modification may be increased considerably.

It appears that present effort in meteorology has been reduced recently due to new programing of some agencies and the general lack of funds for meteorological research.

The benefits of being able to modify the weather are numerous. Before man conquers space, he should learn about his own environment if he wishes to modify it to the best advantage.

STATEMENT OF CHARLES A. O'HANLON, PRESIDENT, WEATHER MODIFICATION CO., MUNICIPAL AIRPORT, SAN JOSE, CALIF., RE S. 86, A BILL TO PROVIDE FOR RESEARCH IN WEATHER MODIFICATION

Mr. Chairman and members of the committee, I was unable to appear before you during the time of public hearings on bill S. 86 because of speaking engage-

ments in South Carolina. If it is still possible to give consideration to this statement I will greatly appreciate it.

In my opinion the science of weather modification will at some time in the future develop to the point where man will be able to control or greatly modify weather. If this is true, then the further development of this science will have the greatest effect upon our economy, our health, happiness, and lives.

It is, therefore, my opinion that continued research in weather modification is of the utmost importance to the people of our country and that such a research program should be started as soon as possible and continued over whatever period is necessary to develop the answers needed. I feel funds should be made available so that a carefully planned and directed program of research can be set up to continue over a period of several years without fear of the possibility that funds will not be provided in future years.

Such a program should be designed and directed by scientists qualified in the fields of atmospheric physics, meteorology, and chemistry. Such a program should include both basic and applied research. It should include both laboratory and fieldwork.

I feel there is a possible danger of spending years in basic research only, duplicating work already done and ignoring the development that has already been made by scientists in private life and by companies now engaged in weather modification.

It is my opinion that field research programs should be set up in several different areas throughout the country simultaneously to speed up our gaining knowledge under all different climatic conditions.

There seems to be a tendency on the part of some groups to want the Government to finance their individual cloud-seeding programs. I think it would be a mistake to use funds provided under this bill for this purpose. This money should be used for research only. I am, however, in favor of a controlled research program being operated in conjunction with an already established cloud-seeding project where such project or projects will have the necessary meteorological conditions required for the research program. Since these commercial projects already have personnel and equipment this should result in a saving to the Government. Under such an arrangement the group sponsoring such projects would pay for the portion of the program which gives benefit to them only and the Government would pay for the research portion of the program which would be of general benefit.

In view of the above I respectfully submit the following suggestions.

1. That the National Science Foundation be directed to establish a special committee to direct the research program. This committee to be made up of qualified scientists in private life and should include some lay members.

2. That this committee hold hearings from all interested parties before the design of the research program so that those fields of research most needed now may be undertaken.

3. That the development already made by private scientists and operating companies be given careful consideration to prevent duplication of efforts.

4. That the program be designed to include both basic and applied research.

5. That consideration be given to combining some phases of the program with already existing cloud-seeding projects.

6. That funds be made available to provide for a long-range research program.

With the above suggestions incorporated in either the bill or the instructions of this committee which will accompany the bill, I recommend passage of Senate bill 86 as soon as possible.

THE CITY OF OKLAHOMA CITY,
Oklahoma City, Okla., March 14, 1958.

Hon. CLAIR ENGLE,
Congressman from California, House Office Building,
Washington, D. C.

DEAR CONGRESSMAN ENGLE: It has come to my attention that there will be a hearing on March 18 to consider S. 86, a bill to provide funds for weather modification research.

I should like to have the privilege of commenting on the present bill passed by the Senate in that it provides that funds appropriated by Congress will be allocated by the National Science Foundation. I would strongly urge that we add a joint committee of scientists and laymen, to be charged with the duty of advising and working with the National Science Foundation, on the allocation of such funds, as well as administering them.

I have had several years of experience on weather modification, and we have had three highly successful contracts with private enterprise, therefore feel that a great deal of money can be saved, and more progress made if Congress provides an advisory committee to help on the program, primarily for the purpose of taking advantage of the research already made by private enterprise, and the vast amount of experience many of these companies have accumulated to the benefit of weather modification. I would certainly have no objection to the Government agencies having representatives serving as technical assistants, and likewise private operators should be permitted to serve as technical assistants.

We are always in need of weather modification in one form or another, and the drought has emphasized one phase of this program.

If Congress would make funds available for basic research, it would, in my opinion, be making a great contribution to the people of the United States, and I wholeheartedly support this program.

Yours very truly,

MORRISON B. CUNNINGHAM,
Director of Public Works.

BAYSIDE, N. Y., *March 14, 1958.*

Hon. OREN HARRIS,
Committee on Interstate and Foreign Commerce,
House of Representatives, Washington, D. C.

DEAR SIR: This will acknowledge with appreciation notice of public hearings on S. 86, to provide for research in weather modification.

I regret that I will probably not be able to attend the hearings, but would like to support the proposal for more research in weather, although I am not familiar with the provisions of S. 86. The American Meteorological Society, of which I am a past president, has issued a statement on weather modification, the last paragraph of which states as follows:

"All cloud-seeding operations should be considered as experiments, since the techniques are still under development and there is no sound basis for the quantitative estimation of the results in advance of the operation. As experiments, they should be designed primarily to yield optimum scientific results. There is good reason to believe that greatly improved returns from cloud seeding will result from a sound experimental approach, and this should be fostered by all concerned."

Weather modification has vast ramifications in all fields of human endeavor. As an airline meteorologist, I know how effective it would be if some practical means of weather modification could be developed merely to modify fog conditions at an airport. In recent years, hundreds of thousands of dollars were spent on FIDO, the fog-dispersal system at Los Angeles International Airport. Unfortunately, the installation was not a success and had to be removed. One of the larger airlines a few years ago on its own conducted some research in fog dispersal by dropping materials into low-lying fog from an airplane. Although some success was achieved, it was not sufficient to warrant routine use of the procedures.

On a type of more severe weather, the United States Weather Bureau reports that, on the average, 212 tornadoes are reported every year, with an average of 219 deaths per year. On March 18, 1925, 740 persons were killed in an outbreak of such storms. At the present time, man can neither suppress the development nor divert the movement of tornadoes, hurricanes, or other severe storms. However, his aspiration to do so is a highly commendable one, even if viewed only from the material and humanitarian point of view; militarily, there are even greater implications. But we will never know whether man can modify the weather if we sit back and do nothing about it. I believe the attempt to find out through more research in weather modification is highly desirable.

In this connection, may I draw attention to an interim report of the Committee on Meteorology to the National Academy of Sciences-National Research Council, Washington, D. C., entitled "Research and Education in Meteorology," dated January 25, 1958. This report, I think, places research in weather modification in its proper perspective in relation to research in all phases of meteorology. That Committee, composed of eminent scientists, states that "it would be an inexcusable distortion of presently available knowledge and a grievous violation of trust for this Committee to seize upon the single issue of weather control to argue for an expansion in the meteorological research effort

in this country. To start a crash program aimed at achieving a significant measure of control over large-scale weather patterns during the next few years is unrealistic in the light of currently available information."

Discussing further this matter, the Committee goes on to state that, "the road that leads from the type of local weather control represented by these (small-scale) results to control of large-scale weather patterns is long and winding, and there very well may be insurmountable roadblocks that would halt the would-be traveler. Of one thing we may be sure: The kind of research required to find out whether or not such roadblocks exist is precisely the kind of fundamental research that is required to satisfy the intellectual and economic arguments advanced earlier. Specifically, before it will be possible to ascertain the extent to which alteration of natural weather processes is possible in any given instance, it will be necessary to be able to state in quantitative terms what would have happened if man had refrained from interference in that instance. * * * Certainly, research on some aspects of weather control is an appropriate part of an expanded research program in meteorology, but to justify the program solely on that ground or to let weather control studies, as such, dominate the program would be unwise."

With this point of view I am in complete agreement. I note also that the Advisory Committee on Weather Control recommends a broad research program in meteorology. And, since this Committee recommends the enactment of S. 86, I support this bill.

Thank you very much for affording me the opportunity of stating my views.

Yours sincerely,

ARTHUR F. MEREWETHER.

DEPARTMENT OF WATER AND SEWERAGE,
CITY OF SHREVEPORT, LA.,
Shreveport, La., March 17, 1958.

Hon. JOHN BELL WILLIAMS,
Chairman of Subcommittee on Health and Science,
House Office Building, Washington, D. C.

DEAR SIR: I have been requested to place before you in writing my views on water resources development as it applies to water supplies, surface or underground, crop cultivation of all nature, such as cotton, corn, sugarcane, peas, hay, and the like, and forestry of all types. Industry of all description takes its toll of available water; consequently, must be accounted for, to say nothing of pasturelands.

The subject matter in this appeal has become the top question of the day; therefore, should be seriously considered as such, and anything that we do now should be based upon the best thoughts obtainable on this matter. Having been directly connected with 3 contracts on weather modification, 1 having to do with the water supply of the city of Shreveport, and the 2 others on crop cultivation contracts. All three contracts were successfully concluded through the cloud-seeding method. Therefore, know the method and results.

Now that I have briefly stated the nature of my connections and the extent of my experience and interest, will proceed to the question proper.

I understand that on March 18, 1958, a hearing on S. 86, a bill to provide funds for weather-modification research, will be conducted by the House of Representatives committee. The Subcommittee on Health and Science, under the Committee on Interstate and Foreign Commerce, room 1334, House Office Building, Washington, D. C., will conduct it, the chairman of which is the Honorable John Bell Williams. S. 86, I understand, has passed the Senate and, after the above committee action, will be introduced in the House of Representatives.

The bill in its present form placed the funds in the hands of the National Science Foundation for distribution, relieving all outside or private enterprise of any say-so whatsoever in the matter; controlling the funds and knowing that this agency has adverse feelings relative to the subject of this particular weather modification will eventually eliminate the now private enterprises that have done so much to furthering this program, to say nothing of the many dollars spent, from the picture, and deprive us, the little fellow, of an opportunity of contracting with these firms on our own. The burden of carrying the cost of this work individually is more than should be placed upon them, as every person living in the area treated will be benefited, whether they pay or not. We are now processing a law asking the State to take over the question of weather modification, paying for same through taxation. Every human benefits by rains.

A very reasonable rate is now available if the State takes it over. If the United States Government takes it over, proper representation from the people should be in on the deal to insure an equitable disposition of these funds, and enlist the private operators' knowledge and experience on a working agreement with the committee to the end of making an effective organization. This is a very important proposition and should be well handled to meet the demands that they will have to meet.

Effective research should by all means be continued, and the knowledge already acquired the last 10 years by private concerns should be taken into consideration and those concerned serve the United States Government to the best advantage possible.

I think that President Eisenhower's Advisory Committee report on weather control should be utilized by whatever group decided upon, because of the valuable information contained therein; however, in any event, let's not delay assistance to those interested in furthering this work. In my particular case, weather modification has meant much, as the work done here helped me solve what could have been disastrous and costly. To the crops and all other kindred phases of life, the excess rains proved a blessing.

Had I had more time prior to the meeting, I could have made arrangements to attend, which, I know, I would have gained much from.

I wish to state that I have no personal interest in any of the firms engaged in this work, but, from the work that has been done here, can see wonderful possibilities. I wish to identify myself as being superintendent-engineer of the Department of Water and Sewerage of the City of Shreveport, La., for the past 41 years and, prior to that, resident engineer for the Shreveport Water Works Co. for 17 years, and am now vice president of the Red River Valley Water Resources Association, which has to do with the work of weather modification of 5 parishes of the State of Louisiana working over some 2 million acres of land. Two contracts of weather modification have been entered into and completed successfully here within the last 3 years. Please don't misconstrue the intent and purpose of this letter to the committee. I am interested in the successful outcome of this work.

Yours very truly,

THOS. L. AMISS.

NEW YORK FARM BUREAU,
Ithaca, N. Y., March 17, 1958.

Re S. 86.

Hon. JOHN BELL WILLIAMS,
Chairman, Subcommittee on Health and Science,
House Committee on Interstate and Foreign Commerce,
House Office Building, Washington, D. C.

DEAR CONGRESSMAN WILLIAMS: I very much regret that New York Farm Bureau will be unable to have a representative present at your hearing March 18 in connection with weather modification. I hope it will be possible for you to make this letter a part of the record, for we are very much interested in weather modification as it relates to agriculture.

Fruitgrowers in the Hudson Valley for 2 years have invested a lot of money in connection with hail suppression and are in need of help on the part of the Federal Government in this regard.

Last year the size of the operation was inadequate to cope with the size of the storm that occurred, and growers suffered serious losses as a result of hail damage. The annual meeting of New York Farm Bureau adopted the following recommendations:

"That the United States Weather Bureau enlist the cooperation of the best scientists available in carrying on basic research aimed at developing a workable and effective means of hail suppression.

"That, since experiments are already underway in the Hudson Valley, these experiments be continued through grower-Weather Bureau cooperation."

It is our understanding that, if the appropriation is made, the work will be done by National Science Foundation, Washington, D. C., and that Dr. Klopsteg, of that organization, will allocate funds for the different projects to be carried on.

We emphasize the importance of sufficient allocation of funds to carry on and expand the studies and work that has already been done in New York State in connection with hail suppression in the Hudson Valley.

Sincerely yours,

E. S. FOSTER, *Executive Secretary.*

SCHENECTADY, N. Y., *March 17, 1958.*

Senator FRANCIS CASE,
Senate Office, Washington, D. C.:

Other commitments prevent attendance at House hearing relative to their version S. 86. My attitude toward bill remains strongly in favor as indicated by my testimony before Senate hearing last year. Strong and positive Federal support of basic research in atmospheric physics, experimental meteorology, and weather modifications as provided in bill is essential. Federal coordination of this research effort by National Science Foundation in long line established by Advisory Committee on Weather Control is essential for orderly and effective progress in this important field. Please indicate my continued support to House committee conducting hearing.

VINCENT J. SCHAEFFER.

SAN ANTONIO, TEX., *March 17, 1958.*

Hon. JOHN BELL WILLIAMS,
House Office Building, Washington, D. C.:

Strongly urge your complete support of Senate bill 86 to provide funds for weather modification research. I hope provision will be made for Air Advisory Committee of non-Government experts on research and meteorology to allocate funds and designate research projects. Much has already been accomplished and advantage should be taken of information and facts now available.

ALBERT K. MITCHELL, *Albert, N. Mex.*

SAN JOSE, CALIF., *March 18, 9581.*

Hon. JOHN BELL WILLIAMS,
Chairman, Interstate and Foreign Commerce,
New House Office Building, Washington, D. C.:

Potential benefits of weather control to entire Nation are immense. Coordinated research program would be invaluable in development of this new science. Therefore respectfully urge favorable committee report on bill S. 86.

WEATHER MODIFICATION CO.

WASHINGTON, D. C., *March 17, 1958.*

Hon. JOHN BELL WILLIAMS,
Chairman, Health and Science Subcommittee,
House Committee on Interstate and Foreign Commerce,
House Office Building, Washington, D. C.:

American Farm Bureau Federation respectfully recommends the approval of S. 86, to authorize a research program in weather modification. Appreciate incorporation this wire in hearing record.

AMERICAN FARM BUREAU FEDERATION,
MATT TRIGGS,
Assistant Legislative Director.

ATLANTA, GA., *March 18, 1958.*

Hon. JOHN BELL WILLIAMS,
Chairman, Subcommittee on Health and Science,
House Office Building, Washington, D. C.:

The Forest Farmers Association, representing owners of 25 million acres of timberland in 15 Southern States, wants to express its continued interest and endorsement of S. 86. We plan to file a written statement similar to Mr. J. V. Whitfield's statement at Senate hearings last year. We generally support the suggestions of the water resources development corporation as presented by Mr. John Di Santo.

FOREST FARMERS ASSOCIATION,
WALTER MYERS,
Executive Director.

FLOYD E. VOLENTINE & SON,
Shreveport, La., March 17, 1958.

Congressman JOHN BELL WILLIAMS,
House Office Building,
Washington, D. C.

DEAR CONGRESSMAN WILLIAMS: I learned today that you will begin hearings on Senate bill 86, March 18, and wish to take this time to make a few comments on the bill.

The Red River Valley Water Resources, Inc., is an organization of farmers in six parishes in northwest Louisiana. We are organized to promote cloud seeding—when necessary, to assist in increasing rainfall. This project has been successful.

We are definitely interested in S. 86 and testified by mail when this was before a Senate committee.

It is our understanding that you are chairman of the subcommittee which will hold hearings on this bill. We urge you to do all you can to represent us at this hearing.

We do not believe that control of this program should be turned over to a governmental bureau, which in all probability would not use the tremendous amount of information and the facts already in the hands of private enterprise and being used successfully by them.

This program, in our opinion, must be properly organized and administered by a nongovernmental committee assisted by some Government agency designated to serve as technical assistants, along with private operators.

I could write a long letter offering our beliefs in regard to this matter, but do not believe it necessary, and will close with this statement.

We believe as a result of experience and of information we have studied, that it is possible to have weather control, not only by local projects but upon a broad scale global weather pattern.

Therefore, we urge you to provide a working body of private enterprise, individual scientists, civil and military bodies of Government to tackle an all-out approach to winning the race of weather control, as well as provide assistance in obtaining weather modification beneficial to agriculture and city people.

Again urging you to represent us at this hearing, I remain,

Sincerely yours,

FLOYD E. VOLENTINE,
President, Red River Valley Water Resources, Inc.

AMERICAN METEOROLOGICAL SOCIETY

BOSTON, MASS.

STATEMENT ON WEATHER MODIFICATION

[Release May 10, 1957]

The council of the American Meteorological Society has assumed the responsibility for issuing periodic statements on the scientific aspects of weather modification and control. Two previous statements were issued in 1951 and 1953. In view of the additional information on this subject that has become available in the interim the council deems it desirable to issue a revised statement of its opinion at this time. The statement on weather modification approved by the society's council at a meeting on April 29, 1957, is as follows:

1. The seeding of supercooled cloud with dry ice will usually convert at least a portion of the cloud to ice crystals. Under appropriate conditions such seeding may release variable amounts of precipitation from fairly deep and active cumulus clouds in which the natural release of precipitation has not already started. Small, inactive cumulus clouds are usually dissipated when they are seeded with dry ice. Holes or valleys may be produced in supercooled layer clouds or supercooled fogs by seeding them with dry ice.

2. The injection of water drops or hygroscopic salt particles into active warm (nonsupercooled) cumulus clouds may release some rain. Small, inactive, warm cumulus may often be partially or completely dissipated by seeding them from above with water drops or other particles; such dissipation may occasionally be accompanied by the release of very light rain.

3. In some cases warm fog and stratus may be dissipated in restricted regions by the use of certain hygroscopic materials.

4. At temperatures below about —5° C., silver iodide crystals are known to affect supercooled clouds in much the same way as dry ice. The frequent absence of clear-cut results following the operation of ground-based silver iodide generators is believed to be due to one or more of the following causes: (*a*) The failure of the seeding material to reach the supercooled clouds; (*b*) the absence of clouds that could be affected by seeding; (*c*) the decay of the silver iodide; (*d*) the presence of an ample supply of natural ice crystals; (*e*) topographical influences which defy quantitative measurement.

5. Cloud seeding acts only to trigger the release of precipitation from existing clouds. The release of substantial amounts of precipitation by either natural or artificial means requires the preexistence of an an extensive moisture supply in the form of moist air currents and of active cloud-forming processes. For this reason the meteorological conditions most favorable for the artificial release of precipitation are very much the same as those which usually lead to the natural release of precipitation. This factor plus the extreme natural variability of precipitation makes the evaluation of the effects of seeding difficult and often inconclusive.

6. Evaluations performed by independent agencies have yielded reasonably convincing evidence of increases of precipitation due to the operation of ground-based silver iodide generators only for operations conducted in cold weather in regions where forced lifting of the air over a mountain range is an important factor. No convincing evidence has been presented which indicates that ground-based silver iodide seeding affects the amount or character of the precipitation over flat country. This does not prove that there are no such effects but suggests that if present they are too small to be detected by statistical analyses of data available to this date.

7. In the absence of a truly quantitative theory of precipitation the best present means for obtaining a quantitative estimate of the effect of seeding on precipitation is through the statistical evaluation of randomized cloud seeding experiments. The randomization is necessary to insure valid interpretation of the results and a long series of such experiments may be necessary to detect small effects.

8. Present knowledge of atmospheric processes offers no real basis for the belief that the weather or climate of a large portion of the country can be significantly modified by cloud seeding. It is not tended to rule out the possibility of large-scale modifications of the weather at some future time, but it is believed that, if possible at all, this will require methods that alter the large scale atmospheric circulations, possibly through changes in the radiation balance.

9. All cloud seeding operations should be considered as experiments since the techniques are still under development and there is no sound basis for the quantitative estimation of the results in advance of the operation. As experiments they should be designed primarily to yield optimum scientific results. There is good reason to believe that improved returns from cloud seeding will result from a sound experimental approach and this should be fostered by all concerned.

The society has adopted a policy of issuing statements, to be reviewed annually on a number of weather problems of vital interest to the public. These include the detection, tracking, and prediction of tornadoes and hurricanes; long-range forecasting; fallout of radioactive debris, and other subjects.

MARCH 10, 1958.

To: Chairman, Subcommittee on Health and Science, House of Representatives Committee on Interstate and Foreign Commerce, room 1334, House Office Building, Washington, D. C.

From: Paul J. Caubin, secretary-treasurer of Water Resources Development Corp., 460 South Broadway, Denver, Colo., a private corporation engaged in worldwide weather modification projects.

Reference: Public hearing on S. 86, to provide for research in weather modification, to be held at 10 a. m., Tuesday, March 18, 1958.

Following are my specific recommendations pertaining to this bill:

1. The program must be properly organized and administered by the establishment of a joint committee of scientists and laymen to work within the National Science Foundation. This committee or board should be composed of nongovernmental individuals and should be given full authority and responsibility to administer the appropriation under this bill.

2. No research under this committee should be designed to "re-do" what is aready known. The work of the private operator should be recognized, as well as the findings of President Eisenhower's Advisory Committee on Weather Control.

3. Basic research should be continued and confined to exploring new potentials.

4. Applied research should be accelerated and private concerns must be a part of this program. The physical and engineering side must be emphasized. This is prevalent in all our developmental history. A good recent example is our missile tests—the final work of design improvement must be done through the actual physical testing—the old trial and error approach. This science is no different. Another 10 years could be lost in the laboratory if we don't face facts.

5. In the apportionment of any funds available under this legislation, consideration should be given—

(*a*) In assisting those groups of individuals that have supported this work over the past 10 years with their own funds.

(*b*) To provide funds for State governors or State agencies to handle such activities within the States.

(*c*) To recognize and assist those private enterprise operators that have struggled unceasingly, against many odds, to progress this science.

(*d*) To set up a working body of private enterprise, individual scientists, and civil and military bodies of government, to tackle an all-out approach to win the race of weather control.

Please accept the following pages as part of my testimony on this matter.

PAUL J. CAUBIN.

My name is Paul J. Caubin and I am secretary-treasurer of the above-mentioned corporation, a private enterprise organization actively engaged in the operation of weather modification programs throughout the world, from initial research and development in 1946, to the first commercial applications in 1950.

I personally attended the recent hearings of your group on this vital subject on May 13, 1957, in Capitol Building, room G–16.

I respectfully urge and request your committee, because of the extreme and far-reaching impact of this bill, to accept and enter this memorandum and appendixes thereto, as a matter of record.

From testimony I heard and have since studied, there are certain misunderstandings and statements of only partial fact that may hinder the clarified rendering of final action.

In addition, I feel it a duty as a private citizen of this great country, to voice an opinion and refer to facts to attempt to prevent the veiling of the economic benefits of weather modification.

Throughout the eons of the history of our world, excluding those military periods, the progress of free democratic countries has been directly tied to the sincere efforts of the individual citizens. It has not been best served by the gargantuan progression of bureaucratic governmental agencies demanding vast sums of tax funds with inherent high percentage factors of duplicity and waste. In addition, such mere existence of agencies demands expansion, regardless of the validity of functions. Also there is the definite tendency of the bureau to render the basic constitutional functions of the Senate and House and the members of such, into the role of servant and not master.

No sincere citizen of any country of democracy desires not to pay the price for freedom and good government—but does desire economy, efficiency of operation and the service to the true aims of such government. Today we can readily see the signs wherein broad bureaus, expending enormous sums of tax funds, are meeting the equalizing factor of the spontaneous rigidity of the will of the individual taxpayer.

At the hearings which I refer to, I listened carefully to the testimony of the governmental bureaus, especially that of Dr. Reichelderfer, of the United States Whether Bureau. He made such statements as:

"The estimated cost of past cloud seeding experiments by the Federal Government is of the order of $10 million."

"A review of the extensive experimentation in cloud seeding which has been undertaken throughout the world, indicates that the results to the present time have been inconclusive and indefinite."

Now, conversely, let's look at the progress factually achieved for one-tenth the research costs. This, then, does not demonstrate the practical sense of again waiting another 10 years for indefinite answers from governmental bureaus. This, too, represents only strides made within our own organization.

Let's not assume a one-sided record nor that it requires a governmental bureau to progress a science.

The following developments of major importance were achieved by Water Resources Development Corp. during the period 1946 through 1956:

1. Development and perfection of the first successful coke-burning ground generator capable of effectively producing rainfall increases over what may naturally occur.

2. Developed two successful techniques to properly trace from ground to air the dispersion, rate of rise and plume effects of ground generator particles in the free atmosphere. This accomplished through the use of "no lift" balloons with theodolite tracking and dispersing of a fluorescent particle readable under "black light." These particles can be collected and plume diffusion plotted by use of our designed airborne instrumentation, flying a predesigned collection course.

3. Developed and perfected the first workable ground generator with no moving parts and an operational-failure design of 1 time in 2 million starts.

4. Researched the first field studies of the physical effects of ground generators on cloud development, not only from theory, but by actually studying physically from aircraft.

5. Developed and designed well-engineered parameters prerequisite to successful operations. Such parameters secured from a detailed analysis of over 300,000 properly logged field operations in many States of the United States and several foreign countries. These allow us to analyze and value such factors as wind directions and speeds at various levels, moisture content of atmosphere, vertical motion of air, freezing temperature levels, inversions, etc.

6. Reviewed and tested all known means of evaluation techniques, and developed a few of our own.

7. Developed and perfected the fuel formula and processes for proper varying concentrations of burning in ground generators, to coincide with atmospheric conditions.

8. Developed and perfected means of postanalysis of weather conditions applicable to project areas to predetermine possible chances of success.

9. Developed and perfected electronic reading units to give advance warnings of hail and lightning potential prior to any possible chance of warning by radar.

10. Developed one of the best nuclei counters in the world.

11. Developed mechanical and slide-rule type instruments to hasten the plotting of predetermined plume diffusion charts prior to starting generator operations.

12. Developed long-term studies of readings of natural nuclei counts in great segments of the United States.

13. Developed the first practical ground-based generator operation of hail-suppression procedures. We made proper laboratory studies to determine chances of success of hail suppression. Then, with high loss factor of human life, actually gained our practical knowledge of hail formation and effects of certain chemicals on reduction by physically flying into and through hail-forming and bearing clouds. Our physical observations were properly logged reflecting the natural development. Then, releasing high concentrations of chemicals from aircraft within the cloud, we truly observed the effects of such chemicals on natural hailstones. In other words, our successes in suppression of hail is not based on idle theory, laboratory fancy, or speculation, but on human physical observation within existing atmospheric conditions.

14. Performed the first successful flatlands ground-generator type of weather modification.

15. Developed the first practical ground-based generator to release salt particles for the seeding of warm clouds. Have performed such commercial operations for sugarcane industry in French West Indies with good results.

16. Developed instrumentation for the control of operations to assist in the location and suppression of lightning.

17. Made some of the first studies of the potentials of wind, tornado, and hurricane suppression.

18. Developed one of the first means of progressing the installation of radio or telephone-controlled generators to operate from centrally located control panels.

19. Developed an integrated central and local control of project area operations to insure greatest introduction of all factors of technical personnel.

20. Developed the largest private weather analysis and control center in Denver in the world.

21. First to apply the use of electronic computing brains, Univac, to assist in determining chances of rainfall increases in project areas.

22. Performed the first controlled ground generator randomized seeding project in Israel. It was calculated that it would require about 100 years of operations by this selective method to acquire results that may be evaluated.

23. Performed the first mass ground seeding to determine if man could overseed and therefore suppress rain.

Such positive progress for a fraction of funds expended by Government bureaus reflects the savings and ability of private enterprise to get the job done. It negates the contention that Government bureaus should spend the appropriations of Senate bill S. 86.

To further emphasize the positive side of the successes being achieved throughout the world, may I quote excerpts from and refer you to the complete reports of—

A. The second report on cloud-seeding experiments over Sun Moon Lake area by Taiwan Rain Stimulation Research Institute, T'ai-pei, Taiwan, China, April 1956, states: "Counting for the irregular climatic fluctuations and the statistical errors, one may conclude that the rainfall at the target area, the vicinity of the upper streams of Sun Moon Lake, did increase due to the cloud-seeding activities, and the average increase in rainfall during the 1951–52, 1952–53, and 1953–54 Sun Moon Lake dry seasons is 15 percent."

B. Report No. 341, prepared by American Institute of Aerological Research on the Water Resources Development Corp. operations in the island of Grande Terre in the French West Indies, reflects the proportional increase in precipitation occurring over the sugarcane plantations, appears to have been of the order of 10 percent—as promised client by Water Resources Development Corp. in a preoperational survey of potentials.

C. A report by E. G. Bowen, radiophysics division, Commonwealth Scientific and Industrial Research Organization, of Sydney, Australia, reporting on seeding operations in the Snowy Mountains area of Australia, reflects: "The experiment has been in progress 9 months and the results are not expected to be statistically significant until approximately 24 months have elapsed. However, up to the present time, there is a net increase of 30 percent in the precipitation in the target area." (Extracted from proceedings of the conference on the scientific basis of weather modification studies, April 12, 1956, at Institute of Atmospheric Physics, University of Arizona, Tucson, Ariz.)

D. Also at this same conference, Dr. H. Weickmann, Signal Corps Engineering Laboratories, Fort Monmouth, N. J., reported on stratus cloud seeding in Western Germany, January and February 1956, as: "While any conclusions at this time must be preliminary, it can be said that the results of the tests confirmed the encouraging results obtained previously in the United States."

E. A report of artificial snowfall from mountain clouds in Scandinavia by F. H. Ludlam, reprinted from Tellus, volume 7, No. 3, August 1955, reads: "The estimated maximum attainable increases in the mountain snow cover and spring flood discharge of the rivers in the region considered amounts respectively to about 10 percent and 25 percent of the normal values. Such increases would be easily noticeable. However, it must be emphasized that these estimates are tentative, and it is unlikely that present seeding techniques have a very high efficiency."

F. The division of hydrology, Électricité de France (whose head is also president of the French Meteorological Society) under direction of studies and research applied statistical tests to the control of cloud seeding operations in their report of October 1956, reflects: "For the first winter, significant increase (1954–55) of 42.3 percent; for the second winter (1955–56) of 78 percent; for each year taken individually, 1954–55, 26.5 percent; 1955–56, 19 percent; for the series of 2 consecutive years, 1954–56, 23.7 percent; all this allows us to state increases experienced on the annual scale are very similar to those indicated by the Advsory Committee on Weather Control. They are even a little greater, doubtless due to the excellent natural location of the watershed and the competence of the operating company, which was Water Resources Development Corp., of Denver, Colo."

G. President Eisenhower's Advisory Committee on Weather Control noted that: "The Committee's staff has analyzed, statistically, a project in Switzerland, carefully conducted under scientific auspices, and the analysis shows a

50 percent reduction in hail. Personal testimony from an area visited by Committee members in this country, indicates almost absolute suppression of hail. This evidence is fragmentary. However, it is impressive enough, and the staff's belief in the theoretical possibilities is great enough, to warrant the closest interest in commercial hail suppression projects."

H. A project of rainmaking in Japan, volume 1, 1954, by the committee for rainmaking in Japan, Meteorological Research Institute Mabashi, Suginam, Tokyo reflects: "During the period from September 1953 to February 1954, smoke generators by electric heating were installed at seven different hydropower stations. A statistics analysis of the data of weather supplied from meteorological observatories shows that during this total period, the affected spots had more rainfall in comparison with the not affected spots by 20 percent."

Our organization does not perform so-called hit-and-miss operations or ill-designed programs. We, too, are steeped in proper academic background. For 15 years, our president, Dr. Irving P. Krick, and his colleagues who are now executives of our company formed the department of meteorology at the California Institute of Technology at Pasadena, Calif. In 1948, when Dr. Robert A. Millikan, head of that institution, retired, it was this group that divorced their operation from Cal-Tech to form a nonprofit research foundation, the American Institute of Aerological Research, which is still in existence. It was this foundation that carried on, in 1948, the original work in cloud physics being progressed at Cal-Tech since 1946 and, in 1950, had sufficiently developed proper tested and engineered equipment and techniques to turn over to our above-named commercial company. This foundation continues research, development, and evaluation in this important field.

Since 1950, our commercial company, Water Resources Development Corp., has performed weather modification operations within 27 States of the United States, Canada, and 9 other foreign countries. We have amassed over 650,000 hours of commercial field tests in most of the climatic zones of both hemispheres.

True, in the early period of 1950 and 1951, we were selling short-term projects in any area requesting same. But, we soon realized this would not produce the proper evaluation picture nor afford the opportunity to learn and progress. So, in 1952, we adopted a policy of selectiveness in accepting contracts to insure optimum design and to furnish important data, with emphasis on those areas where small increases and timely rains had most economic potential—South Dakota is one such example.

This 650,000 hours of well-documented data when combined, represents about 40 years of experience, if the projects were progressed in a single location.

Our project areas in the United States are spread from Washington and Oregon, on the west coast, to Georgia and Florida on the east coast. We have gained invaluable experience in mountainous areas, most easily operated, and over flatland areas, which offer different and more complex operational problems. I mentioned this point because of the many references in the testimony of others that flatland operations are not feasible. This is not correct. True, different problems are present, but they have been resolved. Certain weather situations do not respond to cloud seeding over flatland. We recognize and consider this in the evaluation of our capabilities here. Our company has been seeding in flatland areas of the United States and many foreign countries for years and have obtained worthwhile results. It would be safe to state that we have about 325,000 flatland operational hours of well-documented data.

There is no group, private or governmental, that has achieved operational experience over such extensive areas or for such long periods of time over both flatland and mountainous areas as our company. It is the flatland areas that suffer the greatest ravages and repetitions of drought and that do so much to weaken the economy of our country and the world. Therefore, to the logical person, this long record of operational experience would have demonstrated certain obvious facts.

Several of our projects have been under operational contracts since 1950. Surely, no group is sufficiently clever to delude or fool intelligent people for this duration of time.

Our research program has been constructive and progressive. We have covered exhaustively most of the pertinent points of developing a well-engineered product. However, working intimately with the subject day in and day out has brought to our attention many facets that must be continually explored

and developed to further advance this new science. This intimacy with the subject is something like marriage—the faults and good points are brought into sharp focus.

A few of our research-project reports have been printed in scientific journals but many have not. We are a private enterprise and our clients' wishes must be honored. Therefore, a good bulk of our material is not generally circulated or published. However, we have done our utmost to cooperate with the Advisory Committee where requests by this group have been made.

Many argue that ground-based generators cannot effectively emit particles that will rise to proper evaluations in flatland areas to become effective. We have carried on extensive studies to disprove this contention. These studies were made by use of no-lift balloons, special tracer particles released from ground locations and collected by our own designed aircraft collectors, and airborne nuclei counters.

Many statements were made about there being a sufficient number of natural particles present in the atmosphere to stimulate the rain process and that further seeding would have no effect. This statement exposes an ignorance of certain pertinent truths. It is not the number of natural nuclei present that is of most importance, but the moisture content availability and temperature response levels of both natural and artificial nuclei that determine cloud seeding efficiencies. The airstream could be completely saturated with natural particles, and if the other relationships were not present, rainfall would not occur. However, under certain of these situations, the introduction of artificial nuclei from ground generators may materially augment rainfall.

Another point was made that in situations of temperature inversion, any nuclei released at ground level would not reach effective seeding levels. This is partially correct. However, any well-qualified private operator knows these facts and how to properly deal with such situations.

We have performed continuing measurements of natural nuclei counts by placing our counters at strategic points from the State of Washington to the State of Colorado. Daily counts of natural nuclei have been progressed for several years. These data permit factual analysis as to possible effects of both natural nuclei and artificial nuclei on rainfall or cloud development.

Many comments were made concerning necessity of random experiments—but may I quote Capt. Fred A. Berry, scientific adviser to President Eisenhower's Advisory Committee on Weather Control. (Report of Weather Control Research Association Meeting, Edison Building, Los Angeles, Calif., March 23, 1955, p. 62):

"Some of the scientists would like us to quit all this and sit back and wait until they come up with a completely demonstrated and proved theory on how, why, when, and where this works. Some of us have heard this old yarn many times, but there was a lot of agitation before 1900 in England that since the weather forecasts were so poor, they better quit making forecasts until they learned all about the weather. Well, you can see if they had done that, we wouldn't be forecasting yet. There is the thing we know (with what I call a reasonable degree of certainty)—there is an economic benefit back which seems to be slightly greater than the cost, and I don't believe that we should abandon that and sit down and run a randomized experiment for 10 years in order to get a little more firm in our conclusions. Some of us feel that the randomized experiment achieves only one aim which is to destroy half of your data; that you do better if you don't randomize it and use all your data. There are two opposite statistical schools of thought. Our people happen to belong to the one which is against randomization. Now I grant you that we are all for basic research. Just like God, mothers, the American flag, and apple pie on Sunday, everybody's for basic research. Most of us are engineers, too. We can't see any essential conflict. I think you can go ahead with your engineering approach, and as your basic research finds out more about this, you crank that into your engineering and I believe that is the proper way to tackle the thing."

For the record, attached is a bibliography on weather modification and field operations—a record of some of the comprehensive and short reports that have been prepared on weather modification by our group.

PAUL J. CAUBIN.

A Bibliography on Weather Modification and Field Operations Using the Combined Facilities of Irving P. Krick Associates, Inc., American Institute of Aerological Research, Water Resources Development Corp., February 1957

LEGEND

A=American Institute of Aerological Research

C=California Institute of Technology

K=Dr. Irving P. Krick

W=Water Resources Development Corp.

Report No.	Title	Date
1-K	Report on Meteorological Aspects Artificial Nucleation Phoenix Area in Summer. For Arizona Weather Research Foundation.	July 1948.
2-K	Report on Meteorological Aspects of Artificial Nucleation in San Diego Mountain Area in Summer. For irrigation and power interests.	Do.
3-K	Preliminary Report on July Operations of Artificial Nucleation in Phoenix Area. For Arizona Weather Research Foundation.	August 1948.
4-K	Supplement No. 1 to Report on Meteorological Aspects of Artificial Nucleation in the San Diego Mountain Area in Summer. For irrigation and power interests.	September 1948.
8-K	Report on Artificial Nucleation Experiments in the Logo Toronto Area of Mexico. For Cia Agricola Y Fuerza-Electricia Del Rio Conchos, S. A.	November 1948.
10-K	Evaluation of Cloud Seeding Operations in the Phoenix Area During the Summer of 1948. For Arizona Weather Research Foundation.	December 1948.
2A-K	Evaluation of Artificial Nucleation Over the Lake Henshaw Watershed, August 1948 to May 1949. For Vista Irrigation District.	May 20, 1949.
16-K	Evaluation of Cloud Seeding Operations in the Phoenix Area. For the Arizona Weather Research Foundation.	September 1949.
24-A	Progress Report on Survey of Sites in New Mexico Suitable for the Artificial Stimulation of Precipitation Through Cloud Seeding in the Rio Grande Drainage Basin. For New Mexico Development Commission, Santa Fe, N. Mex.	Feb. 3, 1950.
95-W	Survey of Potential Effects of Artificial Cloud Seeding in the Horse Heaven Area. For Horrigan Farms, Prosser, Wash.	Apr. 24, 1950.
27-A	Evaluation of the Results of Aerial Cloud Seeding Operations in the Necaxo Region, Mexico, During the Period June through October 1949. For Compania Mexicana De Luz Y Fuerza Motriz, S. A.	May 1, 1950.
28-A	Prospects for Seeding in the Necaxa Region With Silver Iodide Generators Located on the Ground. For Compania Mexicana De Luz Y Motriz, S. A.	Do.
33-A	Analysis of Cloud Seeding Potentialities To Increase Natural Precipitation in Southeastern Colorado. For Southeast Weather Research Association.	June 29, 1950.
53-A	Preliminary Report of Cloud Seeding Operations, Eastern Washington, June 1950. For Horrigan Farms.	June 29, 1950.
32-A	Analysis of Cloud Seeding Potentialities To Increase Natural Precipitation in Northeastern New Mexico. For northeast New Mexico project. Prepared for Albert K. Mitchell by AIAR.	July 15, 1950.
35-A	Analysis of Cloud Seeding Potentialities To Increase Natural Precipitation in Northeastern Colorado. For Northeastern Colorado Water Development Corp. Prepared for Water Resources Development Corp.	Aug. 1, 1950.
36-A	Analysis of Cloud Seeding Potentialities in Camas Valley, Idaho. For Camas Weather Research Co. Prepared for Water Resources Development Corp.	Do.
40-A	Analysis of Cloud Seeding Potentialities To Increase Natural Precipitation in Morrow, Gilliam and Sherman Counties (Oreg.). For Tri-County Weather Research Corp. Prepared for Water Resources Development Corp.	Do.
39-A	Analysis of Cloud Seeding Potentialities To Increase Natural Precipitation in Antelope Valley, Calif. For Antelope Valley Water Development Corp. Prepared for Water Resources Development Corp.	Aug. 11, 1950.
112-W	Report on Cloud Seeding Operations in Southeast Colorado During July 1950. For Weather Research Association of Southeast Colorado. Prepared for Water Resources Develop-Corp.	Aug. 15, 1950.
38-A	Analysis Cloud Seeding Potential Lewis River Ariel Dam Watershed, Washington. For Pacific Power & Light.	Aug. 20, 1950.
37-A	Analysis of Cloud Seeding Potentialities To Increase Natural Precipitation in Santa Barbara County, Calif. For Santa Barbara County Water Agency. Prepared for Water Resources Development Corp.	Sept. 20, 1950.

A BIBLIOGRAPHY ON WEATHER MODIFICATION AND FIELD OPERATIONS USING THE COMBINED FACILITIES OF IRVING P. KRICK ASSOCIATES, INC., AMERICAN INSTITUTE OF AEROLOGICAL RESEARCH, WATER RESOURCES DEVELOPMENT CORP., FEBRUARY 1957—Continued

Report No.	Title	Date
113-W	Cloud Seeding Operations in Southeast Colorado During August 1950. For Weather Research Corp. of Southeast Colorado. Prepared for Water Resources Development Corp.	Sept. 30, 1950.
115-W	Cloud Seeding Operations in Northeastern New Mexico Area for August 1950. For Eastern New Mexico Weather Research Association.	Do.
43-A	Analysis of Cloud Seeding Potentialities in Sunflower Valley (Calif.) and Adjacent Areas. For Santa Clara County Survery. Prepared for Water Resources Development Corp.	Oct. 9, 1950.
44-A	Analysis of Cloud Seeding Potentialities in Southeast Arizona. For Southeast Arizona Weather Research Corp. Prepared for Water Resources Development Corp.	Oct. 15, 1950.
114-W	Cloud Seeding Operations in Southeast Colorado During August-September 1950. For Weather Research Corp. of Southeast Colorado. Prepared for Water Resources Development Corp.	Nov. 1, 1950.
116-W	Cloud Seeding Operations in the Northeastern New Mexico Area for August-September 1950. For Eastern New Mexico Weather Research Association. Prepared for Water Resources Development Corp.	Do.
54-A	Preliminary Reports (1, 2, 3) on the Analysis of Cloud Seeding Seeding Potentialities of the Upper South Platte Drainage Basin (Colorado). For Platte Valley Water Resources Association.	Nov. 2, 1950.
45-A	Analysis of Cloud Seeding Potentialities in Big Bend Area of Washington. For Big Bend Water Development Corp. Prepared for Water Resources Development Corp.	Nov. 24, 1950.
47-A	Analysis of Cloud Seeding Potentialities in Black River Drainage Basin Above Hatfield (Wis.). For Mississippi Valley Public Service Co. Prepared for Water Resources Development Corp.	Jan. 15, 1951.
48-A	Analysis of Cloud Seeding Potentialities in Plains of Northeastern Colorado. For Northeastern Colorado Water Development Association. Prepared for Water Resources Development Corp.	Jan. 23, 1951.
46-A	Analys's of Cloud Seeding Potentialities in Santa Clara County (Calif.). For Santa Clara County. Prepared for Water Resources Development Corp.	Jan. 24, 1951.
56-A	Report on Cloud Seeding Operations for Camas Valley, Idaho (July, September, October, 1950). For Camas Weather Research Co. Prepared for Water Resources Development Corp.	Apr. 5, 1951.
51-A	Some Evaluations of Sustained Cloud Seeding Operations. By Irving P. Krick and T. B. Smith. Presented at 32d Annual Meeting of the American Geophysical Union at Washington, D. C. Apr. 30, 1951.	Apr. 25, 1951.
50-A	Preliminary Report Cloud Seeding Potentialities Hebbronville Area, Texas. For Brooks-Jim Hogg Agricultural Development Association. Prepared for Water Resources Development Corp.	Apr. 28, 1951.
58-A	Preliminary Report Cloud Seeding Potentialities Brule, Buffalo, Gerauld, Aurora Counties (S. Dak.). For Western South Dakota Rain Increasing Corp.	May 15, 1951.
59-A	Preliminary Report Cloud Seeding Potentialities Southern Utah. For Southern Utah Water Resources Development Corp.	Do.
60-A	Preliminary Report Cloud Seeding Potentialities the Grand River Valley Area of North and South Dakota. For Grand River Valley Weather Improvement Association.	Do.
85-A	Preliminary Report, Cloud Seeding Potentialities Southwestern Nebraska. For Southwestern Nebraska Weather Improvement Association.	May 21, 1951.
71-A	Preliminary Report Cloud Seeding Operations, San Luis Valley, Colo., January 21-April 30, 1951. For San Luis Valley Weather Corp. Prepared for Water Resources Development Corp.	May 23, 1951.
61-A	Analysis of Cloud Seeding Potentialities in Southwestern Colorado. For San Juan Weather Improvement Association. Prepared for Water Resources Development Corp.	May 31, 1951.
62-A	Analysis of Cloud Seeding Potentialities in Laramie County, Wyo. For Wyoming Weather, Inc. Prepared for Water Resources Development Corp.	Do.
63-A	Analysis of Cloud Seeding Potentialities in Baker and Union Counties, Oreg. For Agricultural Interests. Prepared for Water Resources Development Corp.	Do.
93-A	Snow Pack Increase in the Colorado Rockies by Artificial Nucleation. By Irving P. Krick for Research. Prepared for Water Resources Development Corp.	May 31, 1951.

A BIBLIOGRAPHY ON WEATHER MODIFICATION AND FIELD OPERATIONS USING THE COMBINED FACILITIES OF IRVING P. KRICK ASSOCIATES, INC., AMERICAN INSTITUTE OF AEROLOGICAL RESEARCH, WATER RESOURCES DEVELOPMENT CORP., FEBRUARY 1957—Continued

Report No.	Title	Date
64-A	Analysis of Cloud Seeding Potentialities in Southwestern Nebraska. For Southwest Nebraska Weather Improvement Association, Inc. Prepared for Water Resources Development Corp.	June 15, 1951.
65-A	Analysis of Cloud Seedling Potentialities in Southern Utah. For Southern Utah Water Resources Development Corp. Prepared for Water Resources Development Corp.	Do.
66-A	Analysis of Cloud Seeding Potentialities to Increase Natural Precipitation in Brule, Buffalo, Gerauld, Aurora Counties, S. Dak. For Western South Dakota Rain Increasing Corp. Prepared for Water Resources Development Corp.	Do.
72-A	Report on Cloud Seeding Operations Southeast Arizona, Dec. 26, 1950–Apr. 30, 1951. For Southeastern Arizona Water Resources Corp. Prepared for Water Resources Development Corp.	June 21, 1951.
67-A	Analysis of Cloud Seeding Potentialities to Increase Natural Precipitation in the Grand River Valley Area of North and South Dakota. For Grand River Valley Weather Improvement Association. Prepared for Water Resources Development Corp.	June 30, 1951.
68-A	Analysis of Cloud Seeding Potentialities To Increase Natural Precipitation In The Area of Matamoras, Tam, Mexico. For Comite Regional de Defense Agricola. Prepared for Water Resources Development Corp.	June 30, 1951.
69-A	Analysis of Cloud Seeding Potentialities To Increase Natural Precipitation in Coastal Bend Area, Texas. For Coastal Bend Agricultural Committee. Prepared for Water Resources Development Corp.	Do.
78-A	Report on Cloud Seeding Operations, Antelope Valley, Calif. For Antelope Valley Water Development Corp.	July 13, 1951.
83-A	Report on Cloud Seeding Operations Northern Colorado. For Northern Colorado Natural Resources Association.	Sept. 7, 1951.
74-A	A Report on Cloud Seeding Operations in Upper Rio Grande Basin, N. Mex., February–June 1951. For Moisture Production Corp. Prepared for Water Resources Development Corp.	Sept. 28, 1951
77-A	Report on Cloud Seeding Operations, Horse Heaven Area, Washington. September 1950–June 1951. For The Horse Heaven Water Development Corp. Prepared for Water Resources Development Corp.	Do.
78-A	Report on Cloud Seeding Operations, Big Bend Area, Washington, October 1950–June 1951. For the Big Bend Water Development Corp. Prepared for Water Resources Development Corp.	Do.
80-A	Final Report Analysis of Cloud Seeding Potentialities To Increase Runoff in the Columbia River Basin Above Grand Coulee (Wash.). For Bonneville Power Administration.	Sept. 30, 1951.
81-A	Analysis of Cloud Seeding Potentialities in Southern California. For Research.	Oct. 26, 1951.
75-A	Report on Cloud Seeding Operations Southeastern Arizona, Dec. 26, 1950–Oct. 31, 1951. For Southeast Arizona Weather Research Corp. Prepared for Water Resources Development Corp.	Nov. 9, 1951.
79-A	Report on Cloud Seeding Operations for Eastern New Mexico Weather Research Association, Mar. 1–Oct. 31, 1951. Prepared for Water Resources Development Corp.	Nov. 15, 1951.
76-A	A Study of the Weather Factors Which Contribute To Winter Wheat Yields in Morrow, Sherman, and Gilliam Counties, Oreg.	Dec. 3, 1951.
103-W	Analysis of Cloud Seeding Operations for Tri-County Weather Research, Inc. (Oregon) September 1950 through June 1951, final report.	1952.
104-W	Analysis of Cloud Seeding Operations for Southwestern Nebraska Weather Improvement Association, Inc., Apr. 15 through Oct. 12, 1951, final report.	1952.
105-W	Analysis of Cloud Seeding Operations. For Northwest Nebraska Water Resources Development Corp., May 15 through Oct. 12, 1951, final report.	1952.
106-W	Analysis of Cloud Seeding Operations for Border Livestock Association (Texas), Mar. 7–July 15, 1951, final report.	1952.
107-W	Analysis of Cloud Seeding Operations for Coastal Bend Agricultural Improvement Association (Texas), Mar. 13–July 15, 1951, final report.	1952.
108-W	Analysis of Cloud Seeding Operations for Brooks-Jim Hogg Agricultural Development Association (Texas), Mar. 8 through Oct. 31, 1951, final report.	1952.
109-W	Analysis of Cloud Seeding Operations for Weather Improvement Corp., (of Montana), May 15 through Sept. 30, 1951, final report.	1952.

A BIBLIOGRAPHY ON WEATHER MODIFICATION AND FIELD OPERATIONS USING THE COMBINED FACILITIES OF IRVING P. KRICK ASSOCIATES, INC., AMERICAN INSTITUTE OF AEROLOGICAL RESEARCH, WATER RESOURCES DEVELOPMENT CORP., FEBRUARY 1957—Continued

Report No.	Title	Date
110-W	Analysis of Cloud Seeding Operations for North Central Washington Water Development Corp., June 1 through June 30, 1951.	1952.
111-W	Final Operation Report for Southeast Arizona Weather Research Corp., Jan. 1-Dec. 30, 1951.	1952.
118-W	Final Operations Report for Northwestern Colorado Weather Improvement Corp., May 1, 1951-Apr. 30, 1952.	1952.
126-W	Final Operations Report for Western South Dakota Rain Increasing Corp.	1952.
128-W	Final Operations Report for West Central South Dakota Weather Improvement Association.	1952.
151-W	Final Operations Report for Tri-County Weather Research, Inc. (Oregon).	1952.
152-W	Final Operations Report for Blue Mountain Weather Research Association (Oregon).	1952.
153-W	Final Operations Report for Horse Heaven Water Development Corp. (Washington).	1952.
154-W	Final Operations Report for Big Bend Water Development Corp. (Washington).	1952.
155-W	Final Operations Report for North Central Washington Water Development Corp.	1952.
156-W	Final Operations Report for Lincoln Water Development Corp. (Washington).	1952.
303-W	Washington and Oregon, Individual Storm Studies for June 1952. Project covered Big Bend, Blue Mountain, Horse Heaven, Lincoln, North Central Washington, and Tri-County.	1952. 1952.
88-A	Report on Cloud Seeding Operations for El Salvador, C. A. (Mar. 15, 1951-Oct. 31, 1951). For: Cia Salvadorena de Cafe.	Jan. 31, 1952.
89-A	Analysis of Cloud Seeding Potentialities in the Colorado River Basin of Texas. For Lower Colorado River Authority.	Jan. 31, 1952.
101-W	Report of Cloud Seeding Operations, Northwestern Kansas, April to June and August to October 1951. For the High Plains Water Resources Development Association.	Mar. 7, 1952.
70-A	A Report on Cloud Seeding Potentialities in Central Cuba. For American Sugar Refining Co., Cunagua and Jaronu. Prepared for Water Resources Development Corp.	Mar. 25, 1952.
90-A	Final Report, Analysis of Cloud Seeding Operations To Increase Runoff in the Pend Oreille River Basin. For Bonneville Power Administration. Prepared for Water Resources Development Corp.	Mar. 31, 1952.
86	Evaluation of Cloud Seeding by Physical and Synoptic Aprosaches. By Newton C. Stone and Lewis O. Grant. Paper presented at 116th National Meeting of American Meteorological Society, Corvallis, Oreg., June 17, 1952, by N. C. Stone.	July 10, 1952.
91-A	Analysis of Cloud Seeding Potentialities to Increase Precipitation in Tunisia. For M. Leo D'Erlanger.	July 15, 1952.
129-W	Final Operating Report 1952, for Weather Improvement Corp. (Montana).	Oct. 16, 1952.
130-W	Final Operating Report, 1952, for Western South Dakota Rain Increasing Corp. and West Central South Dakota Weather Improvement Association.	Do.
131-W	Final Operating Report, 1952, for North Central Weather Modification Corp. and Southwest Rain Corporation of North Dakota, N D 4 and 5.	Do.
132-W	Final Operating Report, 1952, for Powder River Weather Research Corp. (Weston County, Wyo.), and Powder River Weather Research Corp. (Converse and Niobrara Counties, Wyo.).	Do.
133-W	Operating Report for Southeastern Arizona Weather Research Corp., 1952.	Oct. 24, 1952.
134-W	Operating Report, April-September, 1952, for West Texas Weather Improvement District.	Do.
135-W	Operating Report, 1952, for Panhandle Weather Improvement Association (Oklahoma-Texas).	Oct. 30, 1952.
159-K	Increasing Water Resources Through Weather Modification. Address given at annual meeting of the American Water Works Association, Kansas City, Mo., May 7, 1952. Published in Journal American Water Works Association. Vol. 44, No. 11, November 1952.	November 1952.
136-W	Operating Report, 1952, for Eastern New Mexico Weather Research Association.	Nov. 5, 1952.
138-W	Operating Report, April-September 1952, for T-O Moisture Improvement Association (Oklahoma-Texas).	Do.
137-W	Operating Report, December 1951-September 1952, for San Ysidro Range Improvement Association (New Mexico).	Nov. 20, 1952.
189-W	Operations Report for Northeastern Colorado Water Development Association, February 1951-January 1952, April-September 1952.	Dec. 1, 1952.

A BIBLIOGRAPHY ON WEATHER MODIFICATION AND FIELD OPERATIONS USING THE COMBINED FACILITIES OF IRVING P. KRICK ASSOCIATES, INC., AMERICAN INSTITUTE OF AEROLOGICAL RESEARCH, WATER RESOURCES DEVELOPMENT CORP., FEBRUARY 1957—Continued

Report No.	Title	Date
140-W	Operating Report for Three Rivers Weather Research Corp., April-September 1951 (Montana).	Dec. 2, 1952.
141-W	Terminating Report, October and November 1952, for San Ysidro Range Improvement Association (New Mexico).	Jan. 6, 1953.
117-W	January 1953 in the Pacific Northwest	February 1953.
160-K	Increasing Water Resources Through Cloud Seeding. Address delivered at Second Ohio Water Clinic. Published by Ohio State University, Columbus, Ohio.	Do.
142-W	Final Operating Report for Southeast Arizona Weather Research Association, 1952 excluding May and June.	Mar. 16, 1953.
143-W	Final Operating Report, October-December 1952. For West Texas Weather Improvement District. WRDC.	Mar. 18, 1953.
102-W	Operational Report April-September 1951, WY-1. For Powder River Weather Research Corp.	Mar. 25, 1953.
119-W	Snowpack Operation, Utah, 1952-53. For Richfield, Utah Meeting, Apr. 27, 1953.	April 1953.
120-W	Precipitation Values in Utah, April 1950-March 1951, April 1952-March 1953. For Utah County Commissioners.	Do.
161-K	Evidence of Manmade Climatic Change. Prepared for WRDC by IPK.	Do.
145-A	Final Operating Report, Nov. 8, 1952-Mar. 8, 1953. For Platte Valley Water Users Association and Northern Colorado Natural Resources Association. Prepared by AIAR for WRDC.	Apr. 8, 1953.
98-A	Survey To Determine the Feasibility of Cloud Seeding Operations in Morocco. For Energie L'Electrique du Maroc.	Apr. 10, 1953.
146-A	Supplement to Final Operations Report, 1952. For Weather Improvement Corp. (M-2). Prepared by AIAR for WRDC.	May 1, 1953.
147-W	Operations Report, Nov. 22, 1952-May 22, 1953. For city of Dallas, Tex. Prepared by WRDC for IPK, Inc.	June 9, 1953.
148-W	Operations Report, September 1952-March 1953. For Pacific Power & Light Co. Prepared for WRDC by AIAR.	June 16, 1953.
149-W	Operations Report, November 1952-March 1953. For British Columbia Electric Co., Ltd. Prepared for WRDC by AIAR.	Do.
150-A	Operations Report, Jan. 1-Apr. 10, 1953. For Northwest Colorado Weather Improvement Corp. Prepared for WRDC by AIAR.	June 22, 1953.
144-W	Final Operating Report, October 1952-March 1953. For T-O Moisture Improvement Association.	July 22, 1953.
170-A	Operations Report, October 1952-April 1953. For Panhandle Weather Improvement Association (OTK-1). Prepared by AIAR, for WRDC.	August 1953.
172-A	Operations Report, Apr. 1-May 19, 1953. For North Central Weather Modification Corp. (Ref: ND-4). By AIAR for WRDC.	Do.
182-A	Operations Report for Morocco. For Energie Electrique Du Maroc. By AIAR.	Do.
168-A	Operations Report 1951-52-53. For Western South Dakota Rain Increasing Corp. and West Central South Dakota Weather Improvement Association. By AIAR, for WRDC.	Aug. 20, 1953.
173-A	Operations Report, May-July 1953, MT-1 (Manitoba). For WRDC Modification Corp., Ltd., by AIAR for WRDC.	September 1953.
174-A	Operations Report, Apr. 15-July 15, 1953. For North Central South Dakota Rain Increase Corp. (reference: SD-4), by AIAR for WRDC.	Do.
176-A	Operations Report, May-September 1953. For Platte County Rain Increasing Association (reference: WY-6), by AIAR for WRDC.	Do.
179-A	Operations Report, June 1952-May 1953. For Southern Utah Water Resources Development Corp. (reference: U-1), by AIAR for WRDC.	Do.
183-A	Operations Report, Mar. 27-June 15, 1953. For Box Elder Farms Co. (reference: C-9), by AIAR for WRDC.	Do.
184-A	Operations Report, 1950-53. For Horse Heaven Water Development Corp. (W-1), Big Bend Weather Development Corp. (W-2), Blue Mountain Weather Research Association (O-4), (Umatilla County), by AIAR for WRDC.	Do.
171-W	Cloud Seeding Operations at Dallas, paper by I. P. Krick, presented Oct. 21, 1953, at Southwest Section Meeting, Houston, Tex., WRDC.	October 1953.
(Reprint)	Published in Journal American Water Works Association, November 1953; also paper by K. F. Hoefle, Meeting the Dallas Water Shortage.	
186-A	Operations Report, Jan. 1, 1953-Sept. 30, 1953. For West Texas Weather Improvement District (T-7), by AIAR.	Dec. 1, 1953.
185-A	Cloud Seeding in Israel (Preliminary Report), the Storm, Nov. 17-22, 1953, by AIAR.	Do.
187-W	Increasing Water Resources in Spain, Summary Report (Preliminary), the Rio Alberche Operation. For Union Electrica Madrilena, October 1952 through September 1953, by WRDC in association with Airfleets, Inc.	Dec. 30, 1953.

A BIBLIOGRAPHY ON WEATHER MODIFICATION AND FIELD OPERATIONS USING THE COMBINED FACILITIES OF IRVING P. KRICK ASSOCIATES, INC., AMERICAN INSTITUTE OF AEROLOGICAL RESEARCH, WATER RESOURCES DEVELOPMENT CORP., FEBRUARY 1957—Continued

Report No.	Title	Date
175-A	Operations Report, Apr. 15–Oct. 31, 1953. SD-5, Hyde, Buffalo, Jerauld, Beadle, Aurora, and Hand Counties, by AIAR for WRDC.	January 1954.
189-A	Operations Report, Oct. 14, 1952, to Oct. 15, 1953. For Comanche County, Kans., Woodward County, Okla., Harper County, Okla. (Reference OK-3) by AIAR for WRDC.	Do.
192-A	Operations Report, Weather Modification Project, November 1953. Israel, by AIAR.	Do.
188-A	Report on Hail Suppression Experiment, Conducted for Washington and Logan Counties, Colo., July 2–Aug. 12, 1951. By AIAR for WRDC.	Jan. 8, 1954.
190-W	Report on Weather Modification Operations To Increase Precipitation in Spain, Oct. 1, 1952–Sept. 30, 1953. For the Ministries of Air and Agriculture, Madrid, Spain, by WRDC.	February 1954.
191-W	Report on Weather Modification Operations To Increase Streamflow in the Alberche River, Oct. 1, 1952–Sept. 30, 1953. For Union Electrica Madrilena, Madrid, Spain, by WRDC.	Do.
194-A	Operations Report, Weather Modification Project, December 1953. Israel, by AIAR. (Confidential.)	Do.
196-A	Review of AIAR Field Research in 1953. (Distribution restricted.)	Mar. 1, 1954.
195-W	Typical Cloud-Seeding Operations 1948–53. Seeding manual, by WRDC.	February 1954.
197-A	Operations Report, Weather Modification Project, January 1954. Israel, by AIAR. (Confidential.)	March 1954.
198-W	Report of Weather Modification Operations to Increase Precipitation in Spain. Summary of Ppt. over Iberian Peninsula, October 1952 through December 1953. For the Ministries of Agriculture and Air, Madrid, Spain, by WRDC.	March 1954.
200-W	Lightning Suppression, Aid to Forest Fire Control, by WRDC.	April 1954.
204-K	Technical and Economic Aspects of Weather Modification in Relation to Water Supply. By I. P. Krick. Draft of article prepared for the Institute of Water Engineers, London, England.	May 1954.
205-K	Weather Control Progress, by I. P. Krick. Draft of address presented at annual conference of the American Waterworks Association, Seattle, Wash., May 25, 1954.	Do.
202-A	Operations Report, Weather Modification Project, February 1954. Israel, by AIAR. (Confidential.)	Do.
203-K	Assessing the Value of Cloud-Seeding Operations to Water Supply, by I. P. Krick. Draft of address read by E. M. Frisby at annual conference of British Waterworks Association at Bournemouth, England, June 30, 1954.	June 1954.
208-A	Operations Report, Weather Modification Project, March 1954. Israel, by AIAR. (Confidential.)	Do.
209-A	Cloud Seeding Potentialities on the Island of Grande Terre in the French West Indies, to Syndicate of Producers-Exporters of Sugar and Rum of the Guadeloupe and Dependencies. Prepared for WRDC by AIAR.	June 30, 1954.
210-A	Operations report, weather modification project, Israel, April 1954, by AIAR. (Confidential.)	July 1954.
Correction note	Please change date of publication of Report 191-W to April 1954.	
211-A	Operations report, Dec. 26, 1953–May 2, 1954 (reference: C-8). For Platte Valley Water Resources Association by AIAR for WRDC.	July 15, 1954.
212-A	Operations report, Feb. 12, 1954–Apr. 23, 1954 (reference: WY-7). For Wyoming Weather, Inc., by AIAR for WRDC.	Do.
215-A	Operations report, Nov. 1, 1953–May 11, 1954 (reference: OC-1). For the city of Oklahoma City, by AIAR for WRDC.	July 27, 1954.
217-W	Weather modification operations to increase streamflow in the Alberche River, Spain, 15 months' precipitation summary, October 1952 through December 1953. For Union Electrica Madrilena, Madrid, Spain by WRDC.	July 1954.
214-A	Operations Report, May 15, 1953 to May 14, 1954 (reference: U-1). For Southern Utah Water Resources Development Corp., by AIAR for WRDC.	August 1954.
216-A	Cloud Seeding Review, 1950–54. For Horse Heaven Water Development Corp. (Reference: W-1), Big Bend Water Development Corp. (reference: W-2), Blue Mountain Weather Research Association (reference: O-4), by AIAR for WRDC.	Do.
218-A	Review of Sustained Cloud Seeding Operations in Utah, New Mexico, Pacific Northwest, Colorado Rockies, and Spain. By AIAR for WRDC.	Aug. 11, 1954.
220-A	Water Resources Development Corp. Cloud Seeding Review, 1951–54. For SD-1, 2, 3, 4, 5, by AIAR for WRDC.	September 1954.
223-A	Interim Report on Israel Weather Modification Project. By AIAR.	Do.
222-A-K-WRDC	Hail Suppression Theory and Practice. By AIAR—WRDC—Irving P. Krick, Meteorological Consultant, Inc.	October 1954.

A BIBLIOGRAPHY ON WEATHER MODIFICATION AND FIELD OPERATIONS USING THE COMBINED FACILITIES OF IRVING P. KRICK ASSOCIATES, INC., AMERICAN INSTITUTE OF AEROLOGICAL RESEARCH, WATER RESOURCES DEVELOPMENT CORP., FEBRUARY 1957—Continued

Report No.	Title	Date
206-W	Effects of Climate and Weather on Real Estate Values. By Paul E. Ruch (reprint from the Appraisal Journal of October 1954). Address given to real-estate appraisal group in Chicago, May 7, 1954, by Paul E. Ruch.	May 1954.
219-W	Operaciones de Modificacion Meteorologica Destinadas a Incrementar la Precipitacion en Espana. Examen de la Precipitacion Recibida Durante el Periodo de 18 Meses Octubre de 1952 a Marzo de 1954. By WRDC (Madrid).	August 1954.
224-A	Report on Hail Suppression Project, Mar. 21-June 21, 1954 (reference CA-2). For Placer County Farm Labor Cooperative, California, by AIAR for WRDC.	September 1954.
225-A	Report on Cloud Seeding Operations, July 1953 to July 1954. For West Texas Utilities Co. (reference T-11 and T-12), by AIAR for WRDC.	October 1954.
226-A	Report on Cloud Seeding Operations, May 21-July 28, 1954 (reference ND-4). For North Central Weather Modification Corp., by AIAR for WRDC.	Do.
227-A	Review of Cloud Seeding Operations, October 1953-March 1954 (reference BC-2). For Powell River Co., Ltd., by AIAR for WRDC.	Do.
231-A	Review of Cloud Seeding Operations, August 26-Sept. 30, 1954 (reference: SD-6). For Custer County, S. Dak., by AIAR for WRDC.	November 1954.
228-A	Review of Cloud Seeding Operations, May-July 1954 (reference: SK-1, SK-2). For Weather Modification Cooperative, Ltd., and River Bend Modification, Ltd., by AIAR for WRDC.	Do.
229-A	Review of Cloud Seeding Operations, May 1-Aug. 14, 1954 (reference: MT-1). For Weather Modification, Ltd., by AIAR for WRDC.	Do.
230-A	Review of Cloud Seeding Operations, Apr. 18-Sept. 6, 1954 (reference: WY-8). For Laramie County Weather, Inc., Goshen County Weather Research Association, Niobrara County Weather Research Association, by AIAR for WRDC.	Do.
213-A	Review of Cloud Seeding Operations, Sept. 1, 1953-Apr. 30, 1954 (reference: W-3). For Pacific Power & Light Co., by AIAR for WRDC.	December 1954.
248-K	Weather Modification and Its Value to Agriculture and Water Supply. By Irving P. Krick. Paper given Mar. 4, 1954 by Dr. Krick before Royal Society of Arts, London, England (in form of reprints from April 1954 issue of Journal of the Royal Society of Arts).	March 1954.
236-W	A Study To Determine the Feasibility and Value of Cloud Seeding Operations in the Lebanon, Beirut, Lebanon. By WRDC.	December 1954.
234-A	Operations Report, Weather Modification Project, November 1954, Israel. By AIAR (confidential).	January 1955.
237-A	Hail Suppression Project, Mar. 31-June 21, 1954 (reference: CA-2), Supplement to Report No. 224. For Placer County Farm Labor Cooperative, California, by AIAR for WRDC.	Do.
238-A	Hail Suppression Project Report, Apr. 1-Oct. 15, 1954 (reference: O-5). For Rouge River Valley Traffic Association, by AIAR for WRDC.	Do.
232-A	Operations Report, October 1953 to October 1954 (reference: T-10). For city of Dallas, Tex., by AIAR for WRDC.	Do.
233-A	Operations Report, October 1953 to October 1954 (reference: K-2). For city of El Dorado, Kans., by AIAR for WRDC.	Do.
240-A	Operations Report Weather Modification Project, October 1954, Israel. By AIAR (confidential).	February 1955.
246-A	Interpretation of an Area Average Evaluation of the Effects of Cloud Seeding in Southern Utah. By Hales, Hoffer & Peck for Southern Utah Water Resources Development Corp. by AIAR (reference U-1).	Feb. 10, 1955.
243-A	Operations Report, Oct. 11-Dec. 11, 1954 (reference NC-1). For the city of Greensboro, N. C., by AIAR for WRDC.	March 1955.
242-A	Operations Report, Weather Modification Project, Israel, December 1954. By AIAR (confidential).	Do.
241	Report on Tignes Generator Locations (Weather Modification Project). For Electricite de France by AIAR.	To be published in near future.
250-A	Operations Report, Weather Modification, Project Israel, January 1955. By AIAR. Confidential.	
252-A	Increasing Streamflow and Power Production Through Weather Modification Operations. For Southern Services, Inc., Birmingham, Ala., by AIAR.	April 1955.
251-K	The Application of Weather Modification Techniques to Forestry Problems. By Irving P. Krick. Paper prepared for delivery before the annual meeting, gulf stream section, Society of American Foresters, Biloxi, Miss. May 26-27, 1955.	Do.
249-A	The Potential of Weather Modification Operations to the Banana Groves of the French Cameroon. For La Compagnie des Bananes. By AIAR.	Do.

A BIBLIOGRAPHY ON WEATHER MODIFICATION AND FIELD OPERATIONS USING THE COMBINED FACILITIES OF IRVING P. KRICK ASSOCIATES, INC., AMERICAN INSTITUTE OF AEROLOGICAL RESEARCH, WATER RESOURCES DEVELOPMENT CORP., FEBRUARY 1957—Continued

Report No.	Title	Date
261-A	The Contribution of Cloud Seeding to Arid Land Economy. By Irving P. Krick and E. M. Frisby. Paper prepared for presentation before the AAAS, southwest section, at their annual meeting in Santa Fe, April 24-26, 1955. By AIAR.	April 1955.
257-A	Operations Report (reference: MO-1), Feb. 1, 1954-Jan. 31, 1955. For Springfield, Mo. By AIAR for WRDC.	Do.
263-A	Survey to Determine the Feasibility of Weather Modification Operations for the Lake Chapala and River Lerma Watersheds. For the committee of conservation for Lake Chapala, Guadalajara, Jalisco, Mexico. By AIAR.	May 1955.
262-A	Operations Report, Weather Modification, Project Israel, February 1955. By AIAR. Confidential.	Do.
268-K	Visible Evidence of Economic Benefits From 4 Years of Cloud Seeding Activities Over Southern Utah. Paper read by Boyd E. Quate at 138th National American Meteorological Society Meeting in conjunction with 36th Pacific Division American Association for the Advancement of Science Meeting. June 21-23, 1955. Pasadena, Calif. By Irving P. Krick.	June 1955.
247-A	Report of Cloud Seeding Operations for Lake Lytle, May and June 1955 (reference: T-14). By AIAR for WRDC.	Do.
267-A	Operations Report, Dec. 1, 1954-June 1, 1955. Reference: NV-2, Dec. 1, 1954 to June 1, 1955. NV-3, Jan. 1, 1955-June 1, 1955. For Nevada State Cloud Seeding Committee. By AIAR for WRDC.	Do.
269-A	Operations Report, 1950-55. (References: W-1, W-2, O-4). For Horse Heaven Water Development Corp. (W-1). Big Bend Water Development Corp., (W-2). Mountain Weather Research Association (O-4). By AIAR for WRDC.	Do.
264-A	Operations Report, Weather Modification Project, Israel, Mar. 1955. By AIAR. Confidential.	May 1955.
268-K	Replaced by 271-A.	
271-A	Visible Evidence of Economic Benefits From 4 Years of Cloud Seeding Activities Over Southern Utah. Paper prepared for presentation before the American Meteorological Society, Pasadena, June 21-23, 1955, California Institute of Technology Meeting. By AIAR.	June 1955.
272-A	Operations Report, Weather Modification Project, Israel, April 1955. By AIAR. Confidential.	Do.
273-K	A New Source of Underground Water. By Irving P. Krick, Ph. D., president of WRDC. Paper presented to the Vertical Turbine Pump Association, Dearborn, Mich., June 14, 1955.	Do.
265-A	Report on Weather Modification Operations in the Haut Katanga (Belgian Congo), January-April 1955. For Union Miniere du Haut Katanga. By AIAR for WRDC.	July 1955.
274-A	Comments on Report on Evaluation of Cloud Seeding Operations in Manitoba and Saskatchewan, Circular 2649, technical 215, May 2, 1955. By Warren L. Godson. For George G. Marler, Minister of Transport, Canada. By AIAR.	Do.
275-A	Operations Report, Weather Modification Project, May 15, 1954-May 15, 1955. For Southern Utah Water Resources Development Corp. (reference: U-1). By AIAR for WRDC.	August 1955.
276-A	Operations Report, Weather Modification Project, May 15, 1954-May 14, 1955. For San Juan Weather Improvement Association (reference C-11). By AIAR for WRDC.	Do.
277-A	Operations Report, Oct. 15, 1954-May 31, 1955 (reference: C-8). For Platte Valley Water Resources Association. By AIAR for WRDC.	Do.
278-A	Operations Report, Nov. 15, 1954-June 15, 1955 (reference: WY-9). For WYO-Braska Weather, Inc. By AIAR for WRDC.	Do.
281-A	Summary Report on the Influence of Cloud Seeding During 1951-55 in the Upper South Platte River Basin. For the Denver Board of Water Commissioners. By AIAR (reference: C-8 supplement).	September 1955.
284-A	Precipitation Report C-14, July and August 1955. By AIAR for WRDC.	Do.
282-A	Operations Report, Mar. 15, 1955-June 17, 1955 (reference: OC-1). For the city of Oklahoma City. By AIAR for WRDC.	Do.
286-A	Operations Report, Feb. 3-July 14, 1955 (reference: LA-2). For Red River Valley Water Resources Association, Inc. By AIAR for WRDC.	Do.
288-A	Operations Report, Apr. 4-July 14, 1955 (reference: LA-3). For Northeast Louisiana Weather Modification Corp. By AIAR for WRDC.	Do.
280-A	Report on Hail Suppression Project, Mar. 16-June 16, 1955 (reference: CA-2). For Placer County Farm Labor Cooperative, California. By AIAR for WRDC.	Do.

A BIBLIOGRAPHY ON WEATHER MODIFICATION AND FIELD OPERATIONS USING THE COMBINED FACILITIES OF IRVING P. KRICK ASSOCIATES, INC., AMERICAN INSTITUTE OF AEROLOGICAL RESEARCH, WATER RESOURCES DEVELOPMENT CORP., FEBRUARY 1957—Continued

Report No.	Title	Date
266-A	Annual Report, Israel, July 1953-July 1954, Weather Modification Project. By AIAR Confidential.	September 1955.
291-A	Operations Report, Sept. 1, 1954-Apr. 30, 1955 (reference: W-3). For Pacific Power & Light Co. By AIAR for WRDC.	October 1955.
297-A	Operations Report, Oct. 1, 1954-Sept. 30, 1955 (reference: BC-2). For Powell River Co., Ltd. By AIAR for WRDC.	December 1955.
241-A	Published	April 1955.
295-A	Operations Report (reference: M-5), Sept. 1, 1954-Sept. 30, 1955. For Northwest Water Power Development by AIAR for WRDC. Administratively confidential.	November 1955.
300-A	Report on Hail Suppression Project (reference: O-5), Apr. 1-Oct. 15, 1955. For Rogue River Valley Traffic Association, by AIAR for WRDC.	December 1955.
298-A	Operations Report (reference: QE-1), July 14, 1955-Oct. 8, 1955. For Quebec North Shore Paper Co. by AIAR for Weather Engineering Corporation of Canada.	January 1956.
299-A	Operations Report (reference: QE-2), July 15, 1955-Sept. 15, 1955. For Laurentian Forest Protective Association, Ltd., by AIAR for Weather Engineering Corporation of Canada.	Do.
306-A	Interim Operations Report (reference: GA-1). For East Georgia Weather Modification Association by AIAR for WRDC.	Do.
310-A	Operations Report, Weather Modification Project, Israel, October 1955. By AIAR. Confidential.	Do.
307-A	Operations Report (reference: ON-1, Aug. 14-Nov. 30, 1955. For Abitibi Power & Paper Co., Ltd., by AIAR for Weather Engineering Corporation of Canada.	February 1956.
308-A	Operations Report (reference: ON-2) Aug. 22-Nov. 21, 1955. For Spruce Falls Power & Paper Co., Ltd., by AIAR for Weather Engineering Corporation of Canada.	Do.
309-A	Operations Report (reference: QE-3) Sept. 8-Nov. 30, 1955. For Gatineau Power Co. and Canadian International Paper Co., by AIAR for Weather Engineering Corporation of Canada.	Do.
311-W	Estes Park Ski Snow Survey. For Heron Engineering Co., Denver, Colo., by WRDC. (Distribution restricted.)	Do.
313-A	Operations Report, Weather Modification Project Israel, November 1955. By AIAR. Confidential.	Do.
293-W	Implications of Weather Control, an address given by Paul E. Ruch, vice president WRDC at the annual meeting of the Winnipeg Real Estate Board, Alexandra Hotel, Winnipeg, Canada, Feb. 2, 1956.	March 1956.
314-A	Operations Report (reference: T-13) Jan. 1-Dec. 31, 1955. For Mill Iron Ranches, Denver, Colo., by AIAR for WRDC.	Do.
315-A	Operations Report (reference C-13) Jan. 1-Dec. 31, 1955. For Mill Iron Ranches, Denver, Colo., by AIAR for WRDC.	Do.
316-A	Operations Report (reference: KY-1) Jan. 3, 1955-Jan. 2, 1956. For More Rain, Inc., Paris, Ky., by AIAR for WRDC.	April 1956.
319-A	Operations Report, Weather Modification Project, Israel, December 1955. By AIAR. Confidential.	March 1956.
317-A	Operations Report (reference: LA-1) Jan. 11, 1955-Jan. 10, 1956. For City of Shreveport, Department of Water and Sewage, Shreveport, La. By AIAR for WRDC.	April 1956.
320-A	Operations Report (reference: LA-2) Feb. 3, 1955-Feb. 8, 1956. For Red River Valley Water Resources Association, Inc., by AIAR for Irving P. Krick, Inc., of Texas. (Restricted.)	Do.
329-A	Review of Tucson Conference, Apr. 10-12, 1956, the Scientific Basis for Weather Modification Studies. Paper prepared by E. M. Frisby, M. A. director, Climatology AIAR, for American Meteorology Society meeting, May 14, 1956, Denver, Colo.	May 1956.
331-W	Weather Modification in Theory and Practice. By Irving P. Krick, Ph. D., president WRDC, Denver, Colo.	Do.
323-A	Operations Report, Weather Modification Project, Israel, January 1956. By AIAR. Confidential.	April 1956.
322-A	Operations Report (reference: LA-3) Apr. 4, 1955-Feb. 24, 1956. For Northeast Louisiana Water Resources Corp., by AIAR for Irving P. Krick, Inc., of Texas.	May 1956.
333-A	Operations Report, Weather Modification Project, Israel, February 1956. By AIAR. Confidential.	Do.
330-A	Operations Report (reference: GA-1) Apr. 4, 1955-Apr. 16, 1956. For East Georgia Weather Modification Corp., by AIAR for Irving P. Krick, Inc., of Texas.	Do.
321-A	Report on Cloud Seeding Operations (T-10), Nov. 22, 1952-May 23, 1953, Oct. 12, 1953-Oct. 12, 1954, May 15, 1955-Feb. 29, 1956. For the city of Dallas, Tex., by AIAR for Irving P. Krick, Inc., of Texas.	April 1956.
337-A	Operations Report, Weather Modification Project, Israel, March 1956. By AIAR. Confidential.	June 1956.
334-A	Report on Cloud Seeding in the Upper South Platte River Basin (reference: C-8). For Denver Board of Water Commissioners by AIAR.	Do.

A BIBLIOGRAPHY ON WEATHER MODIFICATION AND FIELD OPERATIONS USING THE COMBINED FACILITIES OF IRVING P. KRICK ASSOCIATES, INC., AMERICAN INSTITUTE OF AEROLOGICAL RESEARCH, WATER RESOURCES DEVELOPMENT CORP., FEBRUARY 1957—Continued

Report No.	Title	Date
335-A	Cloud Seeding To Supplement Municipal Water Supplies. For WRDC, by AIAR. (This report supersedes Rept. No. 331.)	June 1956.
338-A	Operations Report, Weather Modification Project, Israel, April 1956. By AIAR. Confidential.	July 1956.
336-A	Increasing Streamflow and Power Production in Brazos Basin by Means of Weather Modification Operation. For WRDC and Irving P. Krick, Inc., of Texas, by AIAR.	Do.
340-A	Operations Report (reference: FG-1) June 16, 1955-June 27, 1956. For Citizens Water Conservation Association, by AIAR for Irving P. Krick, Inc., of Texas.	September 1956.
343-A	Interim Report on Hail Suppression Operations July 20-Sept. 10, 1956 (reference: AL-1). For Kneehill Hail Suppression Association, Ltd., by AIAR for WRDC Modification Corp., Ltd.	Do.
324-A	Weather Modification Operations To Increase Precipitation in Spain, Oct. 1, 1954-Sept. 30, 1955. For the Ministries of Agriculture and Air, Madrid, Spain by AIAR for WRDC, Madrid, Spain. (Also Spanish edition, same number.)	April 1956.
325-A	Weather Modification Operations To Increase Streamflow in the Alberche and Tajo Rivers, Spain, Oct. 1, 1954-Sept. 30, 1955. For Unión Eléctrica Madrileña, Madrid, Spain, by AIAR for WRDC, Madrid, Spain. (AlsoS panish edition, same number.)	Do.
326-A	Weather Modification Operations To Increase Streamflow in the Jucar River, Spain, Sept. 1, 1954-August 31, 1955. For Hidroeléctrica Española, S. A., Madrid, Spain, by AIAR for WRDC, Madrid, Spain. (Also Spanish edition, same number.)	Do.
327-A	Weather Modification Operations To Increase Precipitation in La Campiña de Córdoba, Spain, Sept. 1, 1954-Aug. 31, 1955. For C. E. P. A. N. S. A., Madrid, Spain, by AIAR for WRDC, Madrid, Spain. (Also Spanish edition, same number.)	Do.
332-A	Report on Cloud Seeding Operations (reference: T-10), Nov. 22, 1952-May 23, 1953, Oct. 12, 1953-Oct. 12, 1954, May 15, 1955-May 14, 1956. For the City of Dallas, Tex., by AIAR for Irving P. Krick, Inc., of Texas.	August 1956.
341-A	Weather Modification Operations To Increase Precipitation in the Island of Grande Terre in the French West Indies, May 19, 1955-Jan. 3, 1956. For Le Syndicat des Producteurs Exportateurs de Sucre et de Rhum de la Guadeloupe, by AIAR for WRDC.	Do.
339-A	Report on Hail Suppression Project (reference: CA-2), Mar. 25-June 25, 1956. For Placer County Farm Labor Cooperative, Inc., by AIAR for WRDC.	September 1956.
342-A	Operations Report May 23-July 5, 1956 (reference: T-13). For Mill Iron Ranches, Denver, Colo., by AIAR for Irving P. Krick, Inc., of Texas.	October 1956.
	Supplement to Report No. 332, Storm Analysis (reference: T-10), Apr. 28-May 2, 1956. For the City of Dallas, Tex., by AIAR for Irving P. Krick, Inc., of Texas.	Do.
344-A	Operations Report, Sept. 1, 1955-Apr. 30, 1956 (reference: W-3). For Pacific Power & Light Co., by AIAR for WRDC.	Do.
346-A	First Draft of Weather Modification Operations Report, 1955-56 (reference: N-3). For Cornhusker Weather Modification Association, Albion, Nebr., by AIAR for WRDC.	November 1956.
345-A	Operations Report, 1955-56 (references: W-1, W-2, O-6). For Horse Heaven Water Development Corp. (W-1 Big Bend Water Development Corp. (W-2), Morrow County Weather Research Association (O-6), by AIAR for WRDC.	Do.
347-A	Operations Report (reference: M-5), Sept. 1-Nov. 25, 1955, Nov. 28-Dec. 21, 1955, July 24-Aug. 31, 1956. For Northwest water power development project, by AIAR for WRDC. Restricted.	December 1956.
350-A	Report on Hail Suppression Project, July 20-Sept. 11, 1956 (reference: AL-1). For Kneehill & Mountain View Hail Suppression Association, Ltd., by AIAR for WRDC and WRDC, Ltd., Calgary, Alberta, Canada.	Do.
351-A	Operations Report, October 1955-September 1956. For Powell River Co., Ltd. (reference: BC-2). By AIAR for WRDC.	Do.
349	Operations Report, May 25-Sept. 11, 1956. For Northeast Louisiana Water Resources Corp. (reference: LA-3), by AIAR for Irving P. Krick, Inc., of Texas.	Do.
353-A	Report on Hail Suppression Project, Apr. 1-Oct. 15, 1956. For Rogue River Valley Traffic Association, by AIAR for WRDC.	Do.
352-A	Weather Modification Operations Report, Oct. 15, 1955-Dec. 1, 1956 (reference: N-3). For Cornhusker Weather Modification Association, Albion, Nebr., By AIAR for WRDC.	January 1957.

(Whereupon, at 12:15 p. m., the hearing was concluded.)